MODERN WOUND TREATMENT
AND
THE CONDUCT OF AN OPERATION

BY

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Photo by *Elliott & Fry.*

LORD LISTER.

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PREFACE.

THIS small handbook of "Modern Wound Treatment" is primarily the outcome of gratitude and reverence to the memory of one whose recent death has awakened on all sides a sense of our indebtedness to him as a benefactor of the human race, while it is also a humble attempt to give a fair and correct account of the principles that underlie the method of wound treatment as advised by the late Lord Lister, and at the same time to embody the various modifications and changes that modern advances in bacteriological science have deemed advisable.

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GEORGE THOS. BEATSON.

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Modern Wound Treatment and the Conduct of an Operation.

CHAPTER I.

LORD LISTER'S LIFE AND WORK.

MEDICAL SCIENCE IN THE NINETEENTH CENTURY.

In matters scientific the nineteenth century is distinguished by the intellectual activity that pervaded all branches of learning, especially in the direction of a closer study of nature. Medical Science shared in this spirit of inquiry, and, consequently, made more progress during this era than in all the preceding centuries taken together. Two of its greatest advances were the introduction of chloroform in 1847, and the establishment of the antiseptic system of wound management between 1863 and 1867. Both had their development in Scottish hospitals, the Edinburgh Royal Infirmary being associated with chloroform, and the Glasgow Royal

Infirmary with the origin of antiseptic surgery. While, however, Sir James Simpson, to whom we are indebted for chloroform, was a native of Scotland, being born at Bathgate in 1811, Lord Lister, to whom we owe antiseptic surgery, was of English parentage, and received in England the greater part of his early medical training. As the life history of any illustrious individual always contains an element of human interest, it may not be out of place to touch briefly on the main facts in Lord Lister's career, and to mention the circumstances which led to his coming north of the Tweed, where he inaugurated the great and beneficent work of his life, and conferred on himself imperishable fame.

OUTLINE OF LORD LISTER'S LIFE.

It was at Upton, in the western portion of the county of Essex, and just outside the county of London, that Joseph Lister was born on April 5th, 1827. Since those days Upton has undergone many changes, and it is now a populous district within the burgh of Westham. The house where Lister was born still exists in Upton Lane, Forest Gate, and serves as the Vicarage of St. Peter's Church, which stands close by. As his parents belonged to the Society of Friends, the Quaker schools of Hitchin and Tottenham gave Lister his first education, and from there he went to the University College,

London, where he spent some years in Arts and in Medicine. At the University of London he graduated B.A. in 1847 and M.B. in 1852, and in December of the latter year he was also admitted a Fellow of the Royal College of Surgeons. In the first half of 1853 he acted as house-surgeon to Mr Erichsen at University College Hospital, also finding time to publish several important histological and physiological papers.

In the latter part of the same year he went on a holiday to Scotland, taking with him a letter of introduction to Professor Syme of Edinburgh, who had made a great name for himself by his special diagnostic ability and by his skill as an operating surgeon. Syme gave Lister a hearty welcome, and the outcome of the holiday visit was that Lister remained in Edinburgh and took up clinical work under Syme, who enrolled him at first as a supernumerary dresser and later on made him his house-surgeon. For nearly two years Lister held this appointment, and only resigned it on his election as assistant surgeon to the Edinburgh Royal Infirmary in 1855. With this promotion to the staff of the hospital Lister threw himself with increased energy into the work of the Edinburgh Medical School. He continued to do duty in Mr Syme's wards, but also became an extra-mural lecturer on surgery. As a subject for special scientific study he took up

inflammation, eventually publishing the results of his researches on this important matter in the Philosophical Transactions for 1859. In 1856 Lister still further identified himself with Edinburgh by marrying Mr Syme's daughter.

In 1860 Lister was offered and accepted the Chair of Surgery in Glasgow University, and shortly afterwards in his capacity of Professor of Surgery he became attached to the Glasgow Royal Infirmary. He found its surgical wards a hot-bed of septic diseases, and he devoted his special attention to the elucidation of the cause or causes of this distressing state of affairs. Taking Pasteur's germ theory of putrefaction as the most likely explanation of them, he devised a method of wound treatment, which we now know as the antiseptic system. The principle underlying it and the good results that had followed its adoption were given to the profession in a series of five articles which appeared in the Lancet of March 16th, 23rd, and 30th, of April 27th, and of July 27th, 1867. Each article was entitled "On a new Method of Treating Compound Fractures, Abscesses, etc., with Observations on the Condition of Suppuration," and, collectively, they must be regarded as the first public announcement of the antiseptic system. For two years longer Lister continued to work in the Glasgow Royal Infirmary, leaving there in 1869 to fill the Chair of Clinical

Surgery in the Edinburgh University, as successor to his former teacher Mr Syme.

In his new sphere Lister continued the good work begun in Glasgow. At the Edinburgh Royal Infirmary he further developed his antiseptic treatment of wounds; and when the author served with him as dresser in the summer of 1871, very great advances had been made over the procedures of early Glasgow days. Later on I shall have something to say on these advances, but I may here observe that their distinguishing feature was a desire to make the technique as simple as possible without in any way detracting from its safety and efficiency. For nine years Lister remained in Edinburgh. During the whole of that time his cliniques were attended by large numbers of students as well as by medical men from all parts of the world. In 1877 he accepted the Chair of Surgery at King's College, London, and then once more returned to the city were his early professional studies were carried on. At King's College he taught with great success until 1893, when, at the age of sixty-six, he relinquished the Chair. Three years later, in 1896, he retired from practice altogether, and devoted the leisure thus obtained to scientific pursuits.

In a short notice such as this, space does not permit of my enumerating all the distinctions conferred on Lister, and the compliments paid to

him during the later years of his life. Suffice it to say that he was a man whom all delighted to honour. Queen Victoria, who had created him a Baronet in 1883, raised him to the Peerage in 1897 under the title of Lord Lister, and in 1902 he was made by the late King Edward VII. an original member of the new Order of Merit. His appointment as President of the British Association in 1902 met with universal approval in scientific circles, and it was also felt, when the Jenner Institute of Preventive Medicine was re-organised, under the handsome gift by Lord Iveagh of a quarter million of money, and had to be re-named, that the right thing had been done when it was called "The Lister Institute of Preventive Medicine." After 1908 Lister lived more or less in retirement, and died at Walmer in Kent, on February 10th, 1912. He was given a public funeral in Westminster Abbey, and at it there were present representatives of the King, of Foreign Governments, of all the learned Societies, and of the profession he had so much adorned. An offer of burial in the Abbey was made but was not accepted, as Lister's own wish was that he should be buried in West Hampstead Churchyard beside his wife, who had predeceased him in 1893 after a happy married life of thirty-seven years. This was done, and it may be truly said of him that he was laid to rest amid a nation's mourning and a nation's grief.

LISTER'S PERSONALITY.

Nothing could be more correct and expressive of Lister's personal appearance than Henley's description of him in his sonnet on "The Chief."

> "His brow spreads large and placid, and his eye
> Is deep and bright with steady looks that still.
> Soft lines of tranquil thought his face fulfil—
> His face at once benign and proud and shy."

Recalling Lister as I knew him in Edinburgh from 1871-1874, the years during which I worked under him, I still remember his kind and courteous manner, his earnestness, his unflagging energy, and the enthusiasm with which he inspired all those around him. Other distinctive characteristics of him were the ingenuity, originality, and aptitude that he showed in devising the best means of carrying on the technique of his antiseptic system, as also the attention he bestowed on details. If Genius is an infinite capacity for taking pains, he on that ground alone merited the title. His teaching at the bedside and in formal lectures was always clear, simple, and attractive, and he impressed his students with the care he took in diagnosis, and the well-balanced judgment that he brought to every case. Briefly, I would say that contact with Lister soon revealed the scientific and logical as well as the practical bent of his mind, characteristics which ensured, I am satisfied, his success in a matter where many others had previously failed.

LISTER'S LIFE'S WORK.

1. **Early research work.**—A perusal of Lister's contributions to the scientific journals of his time shows the large amount of original research work that he carried on in his early days. It lay more perhaps in the fields of physiology and pathology than of surgery, but, in connection with the latter, it seems clear that his study of the phenomena of inflammation had satisfied him that it was the decomposition of the discharge in a wound that caused *suppuration*, with a consequent long list of possible evils, and that what was needed was a method of wound treatment that would prevent this sequela. Accomplish this, and surgery would be made safe.

2. **Circumstances that strengthened Lister in his new resolve.**—I think there can be no doubt that there were certain circumstances that must be regarded as additional incentives to Lister in his search for an improved method of wound management. The conditions existing in Glasgow Royal Infirmary in 1860 were one of these circumstances. Not that Glasgow Infirmary was worse than any of the other infirmaries at home or abroad; it was only typical of the state of matters that existed everywhere at that time. Both in hospital and in private practice, suppuration, blood-

poisoning, pyæmia, erysipelas, and hospital gangrene were the common sequelæ of wounds, with the result that many ordinary injuries and many brilliant, well-executed operations ended fatally. A more deplorable state of matters could not well be imagined. The other circumstance that made itself felt was the fact that anæsthetics, by the removal of pain, were extending the field of operative surgery; but advantage could not be taken of this new discovery, because surgeons were deterred from operating by the dread of the disastrous consequences that might ensue. As a consequence of this, the advance of surgical science was delayed. To Lister this prevalence of wound mortality was the pressing question of the day, and to it he devoted his energies.

3. **Lister decided that the germ theory of Pasteur was the basis on which wound management should rest.**—The problem that Lister set himself to solve was the difficult one of determining the factor or factors that caused suppuration and its sequelæ in wounds. He felt that the generally accepted view, that the oxygen of the air was responsible for it, was an erroneous one, and that something more was required to explain it. He considered that the solution of the problem was to be found in some work done by Pasteur,

in which the great scientist had shown successfully that the doctrine of spontaneous generation was untenable, and that the cause of putrefaction and fermentation was the presence in fluids of minute organisms or "germs," as he termed them. It was the presence of these so-called germs in the discharges of a wound that Lister regarded as the cause of their decomposition with its consequent suppuration and ill effects, and he formed the opinion that exclusion of these minute organisms from wounds would lead to the disappearance of all septic complications. It was on this principle that he established his new method of wound treatment, and it was the basis of his work from the very first, and of the technique that he devised. Of his indebtedness to Pasteur, Lister was always ready to make acknowledgement, and at Paris, in 1900, at the Thirteenth International Congress of Medicine, he publicly stated that he had done no more than seize upon that scientist's discoveries and apply them to the work of surgery; while on 13th February 1874, he wrote as follows to Pasteur:—"Allow me to take this opportunity to tender to you my most cordial thanks for having, by your brilliant researches, demonstrated to me the truth of the germ theory of putrefaction, and thus furnished me with the principle upon which alone the antiseptic system can be carried out."

The evolution of the technique of antiseptic surgery.—Having adopted as the working basis of his wound treatment Pasteur's germ theory, Lister saw that the application of it involved the carrying out of the following principles:—

(1) In the case of injuries with open wounds, any organisms that had gained admission must be destroyed.
(2) In the case of operation wounds, no organisms must be admitted during the operation.
(3) In both classes of wounds, protection by suitable dressings must be provided during healing.

These principles could not, however, be put into practice without the aid of a germicide or antiseptic, and after a trial of different substances, Lister was led to use carbolic acid as the most suitable for surgical work. In it he placed implicit confidence all through his carecr as a surgeon, though he ultimately exchanged the carbolic gauze as a dressing for that of the double cyanide of zinc and mercury. In the matter of preventing the admission of micro-organisms to wounds, Lister from the first recognised an outside channcl of infcction—the hands of the surgeon, of the assistants, and of the nurses, the skin of the patient, instruments, sponges, all surgical accessories, such as

ligatures, sutures, and drains, and the surgical dressings employed, and measures were taken to purify them and render them antiseptic. Another belief that Lister held very strongly at the first was that the air was a special medium of contamination, and for a time he invariably used a "spray" of carbolic acid to render the atmosphere surrounding a wound quite free of germs.

For testing his plan of antiseptic treatment, Lister took first, as already mentioned, compound fractures, a class of injury dreaded by hospital surgeons owing to their heavy mortality, even after amputation, which was found necessary in many cases. The new method of procedure adopted with them was to wipe out carefully the interior of the wound with undiluted carbolic acid, with the object of destroying any septic organisms that had gained admission. As a protective dressing to exclude all further mischief, two layers of lint, also saturated with the undiluted acid, were laid over the wound, so as to overlap it on all sides for at least half an inch. Above this was moulded a piece of thin block-tin, which was fixed on by strips of adhesive plaster, and served as a cover to the crust made of blood and lint. Once a day the tin cap was removed to allow of this crust being painted on its outer surface with the carbolic acid, this procedure being continued until the wound

was superficial, when the crust was removed and simple dressing applied.

Marked success attended this form of dressing, and Lister was encouraged to deal with abscesses and other surgical ailments. Equally gratifying results followed with them, and with the experience gained, Lister further modified and developed his technique. It would be impossible in a short sketch such as this to enumerate all the changes in dressings and accessories that Lister introduced from time to time, and that represent the different phases through which the antiseptic system passed since the days when there was used the first simple dressing described above. They have been clearly and attractively described by Sir Hector Cameron in his James Watson Lectures on the Evolution of Wound-Treatment during the last Forty Years, and as the lectures have been issued in book form they are easily accessible. A perusal of this brochure reveals the many efforts made by Lister to simplify as much as possible the means of carrying out his method of wound-treatment, without in any way impairing its efficiency. Frequently we find the various materials employed superseded by newer and better substitutes, and even the at one time indispensable "spray" abandoned, until by degrees a high standard of perfection was attained, and Lister, on his retirement from active surgical work,

was able to bequeath to the profession a very efficient and easily managed system of wound treatment. This was not accomplished, as Sir Hector Cameron has pointed out, "without labour and toilsome investigation and experiment of which few can have any adequate idea." In illustration of this may be mentioned the catgut ligature, which took the place of the abandoned carbolised silk one, and received from Lister constant thought and study for at least a dozen years before he considered it perfect.

Another reason for the modifications made by Lister at different times in his system was the increased knowledge that was being acquired of *bacteria* in general, and specially of those connected with surgical diseases. When Lister began his work, practically nothing was known about micro-organisms and their effects, and his first idea was that putrefaction in wounds was the cause of all the fatal results following injuries and operations. Gradually, from what he had observed in certain cases, the conviction was forced upon him that this was not the full explanation of the matter, and he began to hold the opinion that possibly different septic diseases were due to different kinds of organisms. This surmise was subsequently verified by the work of Billroth, Recklinghausen, Klebs, Ogston, Fehleisen, Loeffler,

Rosenbach, and others, their labours materially serving to establish that science of bacteriology with which we associate the name of Koch, and that has so largely added to our knowledge of the different micro-organisms with its accompanying progress in a proper conception of the true nature of infective diseases.

Recent alterations in the technique of antiseptic surgery.—Of late years still greater changes than any of those alluded to above have taken place in the antiseptic management of wounds. To three of these I wish specially to refer. The first one is the substitution of some form of mercurial solution for carbolic acid as a germicide. No doubt Koch's researches showing the great value of the solutions of corrosive sublimate as destroyers of micro-organisms were responsible for this, and they made an impression on Lister, who experimented with them as a dressing, his investigations ultimately taking the shape of a gauze impregnated with a double cyanide of mercury and zinc, of which he had the highest opinion. Indeed, in his latest utterance on it he expressed regret that it was not more generally used, especially in foreign countries.

The second most important departure to be noted is the more elaborate method now in vogue for the

preliminary sterilisation of the patient's skin at the site of operation and its vicinity. As carried out in the present day, the process is a most prolonged and elaborate one, a prominent feature of it being the scrubbing of the part with a nail-brush for several minutes. To such a length has this gone, that there are signs of a reaction having set in, and surgeons are very properly beginning to ask the question, whether it may not be overdone and harm ensue.

The third and last change to which I would refer is the marked reaction that has set in against the use in surgery of chemical antiseptics, and the substitution for them, wherever it is possible, of heat as the sterilising agent of everything that comes or may come into contact with the wound. It is to Germany and America that we are indebted for this innovation in wound management, and for the term "*aseptic*" by which it is described. The word has got into such general use that it has evidently come to stay, but it may not be out of place to observe that it is by no means a happy or even correct expression. It was first suggested by Lister as descriptive of a wound that was free from sepsis instead of speaking of it as being in "an antiseptic condition," a phrascology in no way appropriate. This being so, "the aseptic treatment of

wounds" is equally meaningless and absurd, and as Sir Hector Cameron says, "is clearly as confused and inelegant as to speak of "the antiseptic condition of wounds." A further objection to it is that it seems to elevate this so-called "aseptic surgery" into the rank of a new system of wound management when it is nothing of the kind. It is merely a method of surgical technique where the use of chemical substances (antiseptics) is as far as possible avoided in the conduct of an operation, their place being taken by heat.

The early difficulties and ultimate triumph of Lister's antiseptic system.—One of the reasons for the slow progress made at first by antiseptic surgery was the very lukewarm way in which it was received by the surgical world generally, no doubt owing to the fact that like all new teaching it came into collision with the old preconceived notions and the rigid convictions of the day. In this respect it shared the fate that has befallen many other innovations. While, however, Great Britain was apathetic towards the new discovery, the value of Lister's teaching was more quickly recognised by continental surgeons, especially in Germany. Pasteur's countrymen also showed their quick appreciation of the merits of the new system, and put it into practice. Slowly but surely it made

its way, the hostility and ridicule it had given rise to died down, and ere long it entered on its period of ultimate triumph Already the beneficial effects of antiseptic surgery have been conclusively demonstrated and proved, and they are every day presented to us in the great diminution of surgical mortality, the abolition of sepsis in wounds, and the extension of the field of surgery, so that there has been opened up to it the hitherto closed regions of the brain, the chest, and the abdomen. Many are the beneficent effects that have followed the abolition of sepsis in wounds, and when we consider the state of our hospitals before Lister's day, when patient after patient fell a victim to blood-poisoning in some form or other, we feel that he has very properly been likened to Aaron of old "who stood between the dead and the living, and the plague was stayed." Stayed, however, not temporarily but for all time, seeing that Lister's discovery has swept away for ever those septic diseases which were the bane of surgery. He is dead, but his life's work with all its healing powers will continue, so that to generations yet unborn his name will be a cherished memory, and he will be held by them as he is by us in grateful remembrance as one of the greatest benefactors of mankind.

CHAPTER II.

THE PRINCIPLES OF WOUND TREATMENT.

The Fundamental Basis of Wound Treatment.

Whether a wound be caused by the mechanical violence of an accidental injury (trauma), or by the cutting instrument of the surgeon (operation), its modern treatment is based on the universally recognised principle *that all injurious influences must be excluded from it.*

The influences that injuriously affect wounds.

The following are the conditions that are injurious to the safe and quick healing of a wound:—

I. The presence in it of micro-organisms (sepsis).
II. The accumulation in it of blood or of discharges.
III. The gaping or separation of its edges.
IV. Undue movement of it.
V. Interference with the circulation in its vicinity.
VI. The defective application of dressings.
VII. Injudicious after-management.

I. THE PRESENCE OF MICRO-ORGANISMS.

1. Meaning of the term "micro-organisms."

When the expression "micro-organisms" is used, it refers to the microscopic, lowly, vegetable organisms which are known also by the names of "bacteria," "germs," and "microbes."

2. Characteristics of micro-organisms.

They are exceedingly minute in size, it being reckoned that 400,000,000 could be placed on a square inch. In structure they are cellular, but in shape they vary, being globular (cocci), rod-shaped (bacilli), and spiral (spirillæ). Occasionally they are endowed with the power of motion, but their most characteristic feature is the enormous rapidity of their reproduction, the number derived from a single microbe amounting in 24 hours to 16,500,000 (Cohn). Their development is either by *fission* or by *spores*. Sometimes the spores arise within the cells (endospores), but in other cases a division of the organism takes place into a number of elements, of which some are larger and more refractile than the others and behave as spores (arthrospores).

3. General functions of micro-organisms.

They are capable of very powerful vital actions, which come into play in their efforts to obtain

nutrition. They need carbon, hydrogen, and nitrogen, and to get these substances they exercise energetic processes of an analytic and destructive kind upon all the organic material around them In doing this they form new chemical compounds of very varying nature, some taking the form of pigments, some acting as ferments, and some being of a virulent and poisonous character. These last are known as *toxins*, whose entrance into the blood causes fever, delirium, and even paralysis, and, in short, all the symptoms which accompany the infectious diseases. From this it is apparent that the abstraction of materials from the tissues by the bacteria for their own use is entirely a local activity, whereas the deposition of the new products formed, and their absorption, have a general effect, and give rise to constitutional disturbance. This twofold function of these micro-organisms, namely, the abstraction of materials from the tissues for their own use, and the deposition in the tissues of new substances for which they have no use, must be kept in mind.

4. The conditions regulating the life and growth of micro-organisms.

The three essential conditions that they require for their life and growth are (*a*) a suitable soil

for nourishment, (*b*) moisture, and (*c*) warmth. On the other hand, they are adversely affected by light. Even the resistant spores of anthrax have yielded to some hours' exposure to the sun, and a few days of daylight have killed cultures of the tubercle bacillus. The bactericidal rays are undoubtedly the ultra-violet ones. The agents, however, by which they can be most effectually and rapidly destroyed are heat and certain chemical substances known as germicides, of which corrosive sublimate, biniodide of mercury, carbolic acid, zinc mercuric cyanide, creolin, lysol, and carbo-sapol are the ones most in use. In comparison, heat must be regarded as more potent than the germicides.

5. The relation of micro-organisms to oxygen.

This is a very interesting point, and, as regards it, Pasteur was the first to show that there were two groups of micro-organisms, viz., (*a*) those which can grow in air (aërobic), and (*b*) those which cannot flourish in it (anaërobic). Subsequent advances in bacteriology showed that some modification of this assertion was necessary, and it is now generally accepted that, while there are some bacteria that can only exist when oxygen is present in the shape of atmospheric air (obligate

or true aërobia), there are others that, no doubt, flourish best in air but can do without it, obtaining the oxygen they need from the tissues around them (facultative aërobia). In the same way, while there are some bacteria which cannot exist where oxygen is (obligate or true anaërobia), there are others which can live in its presence (facultative anaërobia), though they exist better without it. Consequently there exist "strict aërobes," "strict anaërobes," and "facultative" ones capable of living in either condition.

6. The classification of micro-organisms.

Of the various classifications suggested, the best one probably is that which divides them into the three classes of (*a*) *moulds*, (*b*) *yeasts*, and (3) *bacteria proper*, the last being made up of two large groups known as the (*a*) *saprophytic* or *non-pathogenic*, and the (*b*) *pathogenic*. The first group is connected with putrefactive processes, while the second one, by developing and multiplying within living beings,—in other words by becoming *parasitic*—gives rise in animals and man to those pathological conditions which are known as "infective diseases." It must, however, be understood that the term "*pathogenic*" requires to be taken relatively, for many circumstances determine

it, such as the species of organism and the animal experimented on. In the matter of infection by a pathogenic micro-organism, it is very important to have a correct knowledge of the channel by which the disease has been established, that is to say, whether this has occurred by the agency of the toxins generated, as in the case of tetanus and diphtheria, or through the micro-organism itself, as in anthrax, where the blood-stream and the various organs are invaded by its bacillus.

7. The causal connection of micro-organisms with disease.

The science of bacteriology has given us indisputable proof that suppuration, erysipelas, blood-poisoning (septicæmia), pyæmia, and those other unfavourable sequelæ of wounds that were known by the term "*Hospitalism*," because they were the scourge of our hospitals, and were responsible for the high death-rate in them, are due to micro-organisms, and Koch's postulates have shown that the same origin must be assigned to consumption, typhoid fever, diphtheria, and several other surgical diseases.

8. The variability of micro-organisms.

This question has been much discussed, but there is no proof that a *non-pathogenic* organism can

change into a *pathogenic* one. In the same way *pleomorphism* has not been established, and there is nothing to show that a bacillus can become a coccus or a coccus a bacillus. The mingling of bacteria occurs not infrequently in nature; to it the term *symbiosis* has been given, but in surgical work, where it is also met with, it is spoken of as "mixed infection." It is quite possible that important results may flow from it, and it is a subject not only of interest, but possibly of great practical moment.

9. The habitat of micro-organisms.

They seem to be practically everywhere, save in the air of mid-ocean and on the tops of glacier heights. They float in the air we breathe, they flourish in the water we drink, they exist in the food we eat, they cling to the dust that surrounds us, and they people the upper layers of the ground on which we walk. They live in countless numbers on our clothing, on the surface of our bodies, under the nails of our fingers and toes, in the external ear, in the mouth, nose, and other orifices of the body, and internally in the contents of certain portions of the digestive canal, as for instance the colon.

10. The attributes and rôle of micro-organisms.

As regards their attributes, it is clear that some of them are harmless, some useful, and some productive of disease, so that they play the rôle of both friends and foes of man. As to the real work in the world of these invisible creatures, we are possibly only on the threshold of our knowledge concerning them; but one point brought out by recent researches is that they have opened up a new source of therapeutic remedies in disease. The curative power of the serum of immune animals (serum-therapy), and the striking results obtained by the vaccines made from dead bacteria are now recognised facts, and a wide trial is being given to both sera and vaccines, the latter especially having come into common use.

11. The bacteria of surgical diseases.

Following the suggestion of Roswell Park, it is usual to divide surgical bacteria into two groups, viz. (*a*) *The obligate or true pyogenic organisms*, and (*b*) *The facultative pyogenic organisms.* Each of these groups calls for a few explanatory remarks.

The obligate organisms. Their action on the tissues is of a peptonising or digestive kind, so that we have established a liquefying process which always results in the formation of pus (suppuration).

The following list comprises them:—

1. Staphylococcus pyogenes (*a*) aureus, (*b*) citreus, (*c*) albus.
2. Streptococcus pyogenes.
3. Streptococcus erysipelatis.
4. Diplococcus pneumoniæ.
5. Micrococcus tetragenus.
6. Micrococcus gonorrhœæ.
7. Bacillus coli communis.
8. Bacillus pyocyaneus.

The above are the chief pus micro-organisms with which surgeons have to contend, and of them the *staphylococci* are the most frequently met with, the *aureus* being the most common variety. The characteristic of the staphylococci is that they form localised collections of pus (abscesses), whereas the streptococci choose the lymph spaces and lymph vessels for their extension, and, passing along them with great rapidity, develop a spreading lymphangitis. The streptococci usually occur alone, but sometimes they are found with the staphylococci, forming a "mixed infection." It is from the streptococcus pyogenes that the very useful curative agent the "anti-streptococcus serum" has been obtained. While suppuration is the attribute common to all the pyogenic bacteria, it must not be concluded that they are consequently all alike in their morphology and conditions of growth. The reverse is the case, but

into this point it is not necessary to go here, as a full description of them can be obtained in any work on bacteriology. What has to be borne in mind is that the usual organisms which produce septic mischief are the staphylococcus pyogenes aureus, the staphylococcus pyogenes albus, and the streptococcus pyogenes.

The facultative organisms.—The following are included in this group:—

1. Bacillus of anthrax.
2. Bacillus of tubercle.
3. Bacillus of tetanus.
4. Bacillus of malignant œdema.
5. Bacillus of glanders.
6. Bacillus of diphtheria.
7. Actinomycosis.

The feature of this group of organisms is that they only occasionally lead to the formation of pus (suppuration), their usual effect being the development of certain well-recognised diseases. Actinomycosis stands somewhat by itself. It is an infectious ailment due to the presence in the tissues of a characteristic parasite, the *ray fungus*, which forms hard tumour-like masses on the maxillæ in cattle, and is often termed "lumpy jaw." It belongs to the group of *moulds*, and is one of the two that possess the power of inducing pus-formation.

12. The relation of micro-organisms to ordinary surgical work.

We now know definitely that the micro-organisms we have to dread in our surgical work are *not the ordinary bacteria of putrefaction as Lister first supposed, but they are of a special kind,* their habitat being the dust and organic matter around us, so that they are on the surfaces of all substances exposed to the air, and on which dust can settle. Another point is that *they are not floating about in the air,* except when they have been temporarily carried there by atmospheric currents, after which they again settle down. It has also been conclusively proved *that micro-organisms are not given off into the air from moist surfaces,* but if the water evaporates and they become dried up, then they are liable to be blown about as dust. All of the above facts have a bearing on surgical technique and hospital work. Thus, the knowledge that micro-organisms are not given off from moist surfaces can be utilised in various ways, as in hosing the floor and lower parts of the walls of the operating theatre a few hours before operation; and the fact that dried organic matter can be blown about by the currents of air, should demand the most scrupulous care in hospital wards when dealing with suppurating wounds. None of the discharges should be allowed to drop on the floor of the wards, nor on the bed-

clothes while dressings are being changed, nor indeed, anywhere where they could harden and be disseminated as dust. In the matter of the air also from what has been said, it is evident that it is not injurious in itself, and that it requires no special purification, but it is equally clear that it may be rendered a source of danger by any injudicious procedures on our part that might fill it with dust. Hence the sweeping of wards before the "dressing" of wounds should be avoided, and an operating theatre should be left at rest for some hours before an operation. It should be ventilated, too, without creating draughts and strong currents of air.

13. How to keep wounds free from micro-organisms.

This can only be done by the aid of a special surgical technique, the details of which will be given in the chapter on "*Asepsis and Antisepsis in Surgery.*" That technique is based on the discovery of Lord Lister that suppuration in wounds with all its possible sequelæ is due to micro-organisms, and on the principle that these micro-organisms must be got rid of either by their mechanical removal or by their destruction. On no account must they be allowed admission to a wound, as their presence in it is an element of danger, so that at all times, whenever a wound is being dealt with, there is need

of surgical cleanliness in every detail, and of the closure of every possible channel of infection. These channels are many, for infection may come in the case of operation wounds from without, by way of the skin of the patient, of the hands of the surgeon or assistants; by instruments; by surgical accessories such as ligatures, sutures, drainage materials, and dressings; by the clothing of the patient, operator, or assistants; and by miscellaneous channels as the nozzles of syringes and irrigators, nail-brushes, etc. When the tissues are already infected, as is generally the case in injuries, the surgeon must both correct the mischief already present, and guard against the introduction of any further micro-organisms.

It must also be remembered, although it has no direct bearing on the technique of the surgical procedures during an operation, that infection may come from within the system of a patient through the media of the air, the food, and the drink, as also from a condition of *auto-intoxication*, due to defective elimination of toxic products by skin, lungs, or kidneys, or to perverted physiological processes induced by wrong diet, wrong manner of life, and wrong habits. Deficient depurative action of the liver, and putrefaction of the intestinal contents from the imperfect changes in the food, and from the favourable conditions of bacterial development, are also exciting causes of it. In this way *auto-*

intoxication concerns the surgeon, as it powerfully affects that tissue resistance which is known to be of considerable importance; and the lesson it teaches is that there is need for careful preparation in the case of every patient before an operation, special attention being paid to the correct action of the kidneys, liver, and intestines.

II. THE ACCUMULATION OF BLOOD OR OF DISCHARGES.

Any collection of blood in the interior of a wound is a source of irritation, as it creates *tension* and interferes with the nutritive processes of the part, thereby delaying the healing of the wound. Hence, all hæmorrhage in a wound should be carefully arrested by ligature or otherwise. The materials used for ligatures in antiseptic surgery are—(1) silk and (2) catgut each of them undergoing special preparation for the purpose. To prevent accumulation of fluids in a wound, resort is had to *drainage*, so that provision is made for the free escape of all secretions and discharges. It is a most important and necessary procedure, and may be carried out in many ways as by—(1) glass tubes, (2) rubber tubes, (3) decalcified bone tubes, and (4) drains of (*a*) catgut, (*b*) horse-hair, (*c*) gauze, (*d*) wool, and (*e*) oiled silk. In addition to their employment, valuable help may

be given to the drainage by the *position* of the patient, and by the insertion of the drain at *the most dependent part of the wound.* Upon no point in the management of his cases did Lord Lister speak with

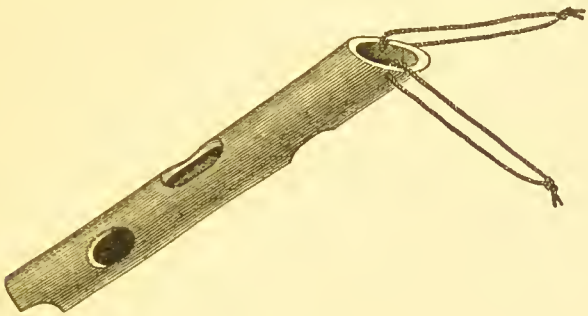

Fig. 1.

more earnestness and clearness than on the necessity of careful attention to this detail of drainage. He favoured the rubber tube, and laid down special

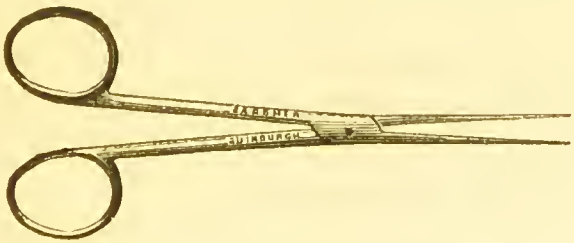

Fig. 2.

directions for its shape and mode of threading it (see fig. 1), and he also introduced a special form of forceps for introducing it, and known as "Lister's Sinus Forceps" (fig 2).

III. THE GAPING AND SEPARATION OF THE WOUND'S EDGES.

This condition would interfere with that rapid union of divided tissues that is so desirable. It is best met by the use of *sutures*, which maintain the edges of the wound in contact. Leaving out "adhesive plaster" (the "dry suture" of the older surgeons), which is occasionally employed after being made antiseptic by the use of carbolic acid for approximating the edges of wounds, the *materials* used for sutures in the present day are as follows:— (1) wire, (2) silk, (3) silkworm gut, (4) horse-hair, (5) catgut, (6) Michel's metallic clips. Speaking generally, it may be said there are two classes of sutures, viz. (*a*) *deep* and (*b*) *superficial*. The latter are used for bringing the actual edges of a wound together, and are sometimes spoken of as *sutures of co-optation*, while the former are used as "buried sutures" or for exercising pressure on the tissues in the vicinity of a wound, so as to bring the deeper parts together and relieve the tension on the superficial stitches. They are called *sutures of relaxation*. Both of these classes of suture may be used in different ways, so that we speak of "interrupted," "continuous," "quilled" (mattress), "button," "Lembert" and other varieties. A description of these can be found in any handbook on surgery. Closely connected with the subject of sutures is that of

surgical needles, and acquaintance should be made with the different varieties of them, such as Glover's, Lister's, Hagedorn's, etc.

IV. UNDUE MOVEMENT.

Nothing is more detrimental to the healing of a wound than unnecessary and excessive movement of the tissues, which may be the result of involuntary muscular twitchings, or by voluntary action on the part of the patient. It is very important that tissues which have been injured or operated on should have *physiological* rest from the products of septic organisms, and also *mechanical* quiet. This latter is best ensured by the use of carefully padded *splints* or *sandbags*, while adjoining muscles should be relaxed, where that is possible, by the posture of the patient or the limb.

V. INTERFERENCE WITH THE CIRCULATION IN THE VICINITY.

This is a matter of *bandaging*. If the bandages that hold on the dressings or the splints are too *tightly* applied, and this is apt to be the tendency especially with students, the circulation in the tissues may be affected, with the result that the part has too much venous blood in it, and the

nutritive and reparative processes do not go on normally.

VI. DEFECTIVELY APPLIED DRESSINGS.

When a wound is undergoing what is known as the "healing process," it has to be equally well protected during that period from the access of micro-organisms. This is accomplished by enveloping it in suitable "dressings," which have been carefully sterilised and otherwise prepared. Consequently, the dressings of a wound have a very important function to fulfil, and it is easy to understand that, if they are scanty and insufficient in *size*, or *applied* in a slovenly way, or too loosely *bandaged*, or insecurely *pinned*, they will not prove reliable, and the wound may become infected and suppurate. It is quite possible for a well-executed and well-planned operation to become a failure owing to badly applied dressings.

VII. INJUDICIOUS AFTER-MANAGEMENT.

The care and after-treatment bestowed on an operation case or on an injury may materially affect the progress of the wound, and it is here

that skilled nursing is of such service. The lifting of a surgical patient, the changing of the dressings, the diet, and many other such matters, are all of the greatest importance, and necessitate the care of an experienced nurse. The key-note of this period in the progress of a surgical case is to anticipate possible complications, and to carry out the old proverb—"Prevention is better than cure."

CHAPTER III.

ASEPSIS AND ANTISEPSIS IN SURGERY.

Now that it has been definitely proved that many of the "*septic diseases*" of surgery are caused by micro-organisms their existence cannot be ignored in surgical work, nor will it suffice to rely on the fact that undoubtedly the cells and fluids of the body possess properties which are actually *germicidal* and inimical to their growth. This *protective power of the body* is a variable quantity, for it is influenced by different factors, such as—(1) the virulence, number, and purity of the *organisms* themselves, (2) the personal habits, environment, and hereditary influences of the *individual* concerned, and (3) the action of the *tissues* affected, not only as regards the vital processes of chemiotaxis and phagocytosis, but also the presence or otherwise of any pre-existing disease or local predisposition, the result of previous injury. Accordingly, absolute reliance cannot be placed upon the body's protective power, especially in the case of *pus-forming* (pyogenic) bacteria, to

which man seems specially susceptible, so that it is necessary to supplement it by a special "*surgical technique*," whose object must be to combat these harmful surgical micro-organisms.

Such a *surgical technique* may be based on any of the following plans :—

(*a*) Preventing the admission of micro-organisms to wounds.

(*b*) Neutralising their effects, should they gain access.

(*c*) A combination of both these methods.

Under the first, very thorough steps are taken by means of heat to ensure that no bacteria reach the wound (*asepsis*), while under the second method there is a more general use of the chemical substances known as *antiseptics*, even to the extent of washing the tissues of the wound with them, so that they may not furnish a nidus where micro-organisms could develop (*antisepsis*). Sometimes both methods are employed either intentionally or under the special circumstances of particular cases. Undoubtedly the surgical teaching of the present day is in favour of the use of *heat* for destroying micro-organisms (*asepsis*) instead of strong *germicides* (*antisepsis*), but the principle underlying them both is the same, and they are merely different ways of carrying out Lister's *anti-*

septic system of surgery. What is spoken of as "*aseptic surgery*" is not a new *system.* It is merely *the employment of a method in surgical technique where the use of chemical substances* (*antiseptics*) *is as far as possible avoided during an operation.* And there is no doubt that clinical experience has shown that *aseptic surgery* has many advantages. Bringing into contact with the tissues of a wound substances that have been rendered surgically clean by heat in the form of steaming or boiling is less irritating to them than lotions of carbolic acid, corrosive sublimate, or other antiseptics, for even weak solutions of the latter cause a temporary *reaction* of the tissues. Thus Halstead has shown that the irrigation of fresh wounds with a corrosive sublimate solution as diluted as 1–10,000 is followed by a distinct necrosis demonstrable under the microscope (Kelly). Such a necrotic layer it is held must interfere with healing and may also serve as a nidus for micro-organisms, while the increased exudation that the *reaction* of the antiseptic induces certainly does. At the same time it must be remembered that under judicious *antiseptic surgery*, where the wound is not deluged with irritating chemical lotions, as good results clinically have been obtained as under the *aseptic* regime, and that possibly the safest plan to follow is to have a combination of (*a*) mechanical, (*b*) chemical, and (*c*) thermic methods, the most

suitable being chosen for each particular detail, one method serving best for one thing and another for another. Certainly there are good grounds for thinking that after an operation *antiseptic* dressings are more reliable than the usual dry *aseptic* ones.

I. THE METHODS FOR PREVENTING THE ACCESS OF MICRO-ORGANISMS TO WOUNDS.

There are two ways in which this may be done—

(*a*) By their mechanical removal.

(*b*) By their destruction.

1. **Mechanical removal.**—Under this are included (1) *washing*, (2) *scrubbing*, (3) *wiping*, and (4) *shaving*. The science of bacteriology has impressed upon us the value of the *mechanical removal* of dirt. It is a method of great use, as it is invaluable for getting rid of bacteria, and it is often an excellent prelude to other means. It is mainly employed in the disinfection of the *skin*, upon which swarms of bacteria are constantly present. As to the form this mechanical removal should take in the matter of the skin, there is, I think, room for discussion. The prolonged course of *scrubbing* with stiff nail-brushes advocated by many for a period of five or even ten minutes, and that by the clock or sand-glass, is open to criticism. There might be circumstances calling

for such a lengthy effort to remove the epidermal cells, but it is quite a debatable point if it is prudent to interfere too much with that protection against infection which the normal and intact skin affords. Machnoff's experiments bear on this point. He *rubbed* agar-agar cultures of anthrax bacilli into the shorn skin of rabbits, and in every case the animal died of acute general anthrax. An examination of the skin showed no microscopical lesions, but anthrax bacilli were present in the hair follicles. In another set of animals, portions of the same culture were simply spread over the skin and no infection followed, showing that the act of *rubbing* had forced the bacilli into the hair follicles. From these latter they entered the tissues and then the circulation, thus setting up a general infection. It is not unlikely that many of the troublesome suppurations of the hands that happen to surgeons, students, and nurses are due to scrubbing with nail-brushes after exposure to pyogenic organisms, thereby forcing these latter into the tissues, notwithstanding the nail-brushes being aseptic. In the same way, too, any violent measures taken for the purification of the patient's skin may be the exciting cause of the often inexplicable "stitch abscesses" that from time to time arise. On these grounds it seems probable that the very necessary and useful procedure of *mechanical removal* should be carried out with

caution. The following points are of practical use in carrying out the mechanical removal of bacteria :—

1. Always shave the part first, especially on the hairy parts of the body.
2. *Pumice-stone soap* is a most efficient soap owing to its mechanical action.
3. Ordinary soap is possibly by no means sterile, and, if employed, it should be combined with an antiseptic, as is done in carbo-sapol, or in other soap solutions, such as Johnston's ethereal antiseptic soap.
4. Wash with sterilised water and, where possible, in *running water.*
5. Confine the use of nail-brushes for scrubbing to the *nails.*

2. Destruction.—This may be accomplished by (1) *heat,* or by (2) *chemical agents,* the former being the more potent of the two.

(1) *Heat* has of late come largely into use in surgery, superseding to a great extent chemical agents. It is of course more troublesome to manage and takes longer time, but it is very reliable. It may be employed in any of the three forms—(*a*) *hot air,* (*b*) *boiling water,* and (*c*) *steam.*

Hot air is very little used, as it is not

nearly so powerful an agent as the other two, owing to its non-penetrating power, so that things require a very long exposure to it. *Boiling water* and *steam* are the two methods most in vogue in surgical work, and special apparatus has been devised for "*sterilising*" or making "*surgically clean*" instruments and dressings by means of it. Remember, however, extempore arrangements can always be made. Although great variations of temperature can be borne by mature bacteria, especially by their spores, the two following axioms may be accepted for ordinary surgical work:—

1. *Boiling for ten minutes* will destroy any of the surgical bacteria and their spores, if not enveloped in *dried pus and blood.*

2. *Exposure to steam heat at* 100° *Cent.* (212° *Fahr.*) *for half an hour under ordinary pressure* will render quite sterile all cotton, gauze, bandages, and other dressings, provided they are loosely arranged.

(2) *Chemical agents.*—The substances available for "chemical sterilisation" are known by the different names of *germicides, antiseptics,* and *disinfectants.* These terms are not

altogether identical. *Germicides* actually kill bacteria and their spores. *Disinfectants* not only destroy bacteria, but also the noxious products of fermentation and putrefaction. *Antiseptics* inhibit bacterial growths, and so prevent *sepsis* or putrefaction.

A great variety of chemical agents have been employed in surgical work, but many of them have had only a temporary reputation. *Carbolic acid*, from its association with Lister's earliest work in antiseptic surgery, held undisputed sway for a long time, but it has found strong rivals in other of the coal-tar derivatives like lysol, creolin, and izal, and still more so in the *salts of mercury*, as corrosive sublimate and the biniodide. Other substances found efficient and useful are certain *oils*, as of turpentine, juniper, and cloves, *mercuro-zinc cyanide*, a double salt of zinc and mercury, *boracic acid*, and *carbo-sapol*, a mixture of equal parts of carbolic acid and soft soap. *Iodoform*, a compound of iodine, is largely used by some. The fact is the ideal antiseptic has not yet been found, and hence the search continues for some soluble, penetrating, actively germicidal, inodorous, and non-poisonous antiseptic. At present the most generally used chemical agents in surgery are—(1) corrosive sublimate, (2) biniodide of mercury, (3) carbolic acid, (4) boracic acid, (5)

mercuro-zinc cyanide, (6) creolin, (7) lysol, (8) izal, (9) carbo-sapol, (10) peroxide of hydrogen, (11) chloride of zinc, (12) salicylic acid, (13) alcohol, (14) ether, (15) turpentine, (16) permanganate of potash (Condy's fluid), and (17) iodoform. There are other substances that have their advocates, but the above are the ones most commonly employed. They are made use of in any of the following forms:—(1) *powders*, (2) *solutions* (*lotions*), watery or oily, and (3) *ointments*.

The antiseptics in general use are :—

1. *Corrosive sublimate.*—Watery solutions, 1-500, 1–1000, and 1–2000.
2. *Biniodide of mercury.*—Spirit solution, 1–500, and watery solutions, 1–1000 and 1–2000.
3. *Carbolic acid.*—Watery solutions, 1–20, 1–40, and 1–60.
4. *Boracic acid.*—Saturated watery solution. As a dusting powder, and as an ointment, boracic acid is also much used.
5. *Carbo-sapol.*—Watery solution, 1–100.
6. *Peroxide of hydrogen* (10 volumes).
7. *Iodoform.*—Powder.

The last substance is only useful in tuberculous and specific cases. It is not a germicide and it is toxic while its odour is most objectionable.

II. MODE OF APPLICATION OF THE ABOVE MECHANICAL, CHEMICAL AND THERMIC METHODS IN SURGERY.

Sources and channels of bacterial infection of wounds.—Excluding *accidental wounds*, which are nearly always contaminated at the time of the injury, it may be accepted as a fact that infection of *operation wounds* comes *from without.* Seeing that bacteria are present in the dust and organic matter around us, it follows that they are on the surface of all substances exposed to the air and that are liable to be covered with dust. Consequently, mischief may be communicated to a wound by the *skin* and *clothing* of the patient, surgeon, assistants and nurses, by surgical *instruments*, by all of the surgical *accessories*, such as ligatures, sutures, drainage materials, dressings, and by outside channels, such as *nail-brushes*, etc. All these avenues of infection must be safeguarded if we are to prevent the admission of micro-organisms into our wounds and secure "*surgical cleanliness.*"

1. Disinfection of Skin and Mucous Membranes.

1. Skin.—Abounding as it does with micro-organisms, a great number of plans have been

suggested for its disinfection, every surgeon having his own method. The following is a simple, quick, and reliable procedure :—

(1) *Shave* the part in the usual way.

(2) *Wash* with fairly hot water and pumice-stone soap, as the latter removes dirt quickly and thoroughly.

(3) *Wipe* the part frequently during the washing with dry swabs of sterilised gauze so as to get rid of the dirt-containing fluid.

(4) *Wash* next with carbo-sapol solution (1-100), wiping the part at intervals with swabs of dry sterilised gauze.

(5) *Rub* next thoroughly and firmly for a short time with gauze swabs soaked in turpentine to get rid of the grease in the skin, wiping off all excess of the turpentine.

(6) *Wash* finally with the strong spirituous solution of biniodide of mercury (1-500), and then dry with sterilised gauze swabs.

The above process should be complete in four or five minutes, and clinical experience has amply proved its reliability. In its details it will be noticed that there is an entire absence of any *scrubbing* of the part with a nail-brush. This is omitted, as it is not necessary and it may do harm. What is of importance is the combination of

washing and *wiping*. It is the latter that really removes the dirt from the part. Everyday experience tells us that after ablution of the face it is the towel that takes away in the drying a large part of the dirt.

Recently, sterilisation of the skin by an alcoholic solution of iodine has been very widely adopted. A 2 per cent. solution of iodine in rectified spirit is the one in common use and is probably the best. In following this plan, care must be taken not to wash the skin with soap and water shortly before the use of the iodine. The following would be the procedure in a case of carcinoma of the breast:— After shaving the axilla, two hours before the operation, the skin in the operation area is painted with the iodine, special attention being given to the axilla with its numerous sweat and sebaceous glands. The operation area is then covered with a sterilised towel. On the operating table the iodine is again applied, and as soon as it has dried the operation may be begun with confidence.

It is of course assumed that an unbroken and healthy skin is being dealt with. Should there be present any scratches, any spots of acne, or any eczema, these would require special attention or even the postponement of the operation. It has been proposed (Albert) to touch acne spots with the cautery.

2. Mucous Membranes.—It is very difficult to carry out our ideal precautions in the case of these surfaces, and we have to be content with *washing*, followed by *wiping* of the parts by swabs of sterilised gauze. Experience has, however, shown that wounds of mucous membranes generally heal satisfactorily, so that the organisms present are probably not of a virulent kind, or it would seem to show that the mere presence of bacteria is not of itself sufficient to interfere with healing.

(*a*) *Mouth and Pharynx.*—Before operation attend to teeth, extracting any carious ones. Wash out the mouth and gargle the throat with warm lotions of boracic acid, or Listerine, and operate only when the gums are healed. Immediately before operation wipe out the parts with sterilised gauze.

(*b*) *Stomach.*—Wash out frequently before operation with warm boric lotion, being specially careful in cases of ulceration.

(*c*) *Rectum.*—Avoid solid food for a few days before operation, and cleanse out the alimentary canal by small doses of castor oil, washing out the rectum itself by enemata of normal saline solution or of soap and water. The evening before the operation give 25 drops of laudanum to

quiet the bowels, and immediately before the operation wipe out the rectum with swabs of dry sterilised gauze.

(*d*) *Vagina.*—Douche out the passage with warm boracic or weak carbolic lotions, and thoroughly wipe it out with swabs soaked in weak carbo-sapol solution. Follow this by a second douching with warm boracic lotion, and then plug the part with iodoform gauze. Just before the operation, withdraw the plug and syringe out again. In carcinoma of the cervix uteri it has been advised to curette and cauterise the part before operation.

(*e*) *Urethra.*—It contains numerous micro-organisms which are with difficulty entirely got rid of. By using a wash-out catheter they may be lessened in number and their growth inhibited by a mild antiseptic lotion.

(*f*) *Bladder.*—In its normal state the bladder is aseptic, and when sepsis has become established it must be met by frequent washing out with warm antiseptic lotions of boracic acid or of weak salicylic acid. In addition, the growth of the bacteria must be inhibited by the internal adminis-

tration of such drugs as urotropin, which leads to the presence of formic aldehyde in the urine and thus acts beneficially.

2. Disinfection of the Hands.

The skin of the hands is the resting-place for micro-organisms of many and various kinds, pathogenic and non-pathogenic, the latter being very numerous. Located deeply in the epidermis and hair follicles, it is almost impossible to affect them by chemical antiseptics or to remove them by any amount of scrubbing. Hence the *sterilisation* of the hands has been found a difficult problem, and very elaborate procedures have been suggested by different surgeons. Others have no confidence in any of the proposed methods, and advocate the use of *rubber gloves*, which can be boiled and thus made absolutely sterile. Excellent and advisable as these are for septic cases and under certain circumstances, clinical experience has shown that the hands may be made *surgically clean* by following a cleansing process based on the same lines as those followed for disinfecting the skin elsewhere, special attention being paid to the *nails*. These latter should be cut short, and all dirt removed from under them and from their roots and sides by a *nail cleaner*, this procedure being repeated during the cleansing process. The steps of this are as follows :—

(1) Remove any rings, and wash the hands and fore-arms in *running* water with pumice-stone soap, scrubbing the *nails* well with an aseptic nail-brush. Let this be done systematically and thoroughly.

(2) Follow this by a similar cleansing in warm lysol or carbo-sapol solution.

(3) Next, wash in a 1–2000 solution of biniodide of mercury, scrubbing the *nails* with an aseptic nail-brush and wiping them and the hands firmly, if desired, with a swab of sterilised gauze soaked in the 1–500 spirituous solution of biniodide of mercury.

(4) Finally, let the hands be rinsed in sterile water, or dried, or proceed to operate without drying them.

Practical experience has shown the above method sufficient for operative work, and from hands so prepared nothing deleterious can enter the wound. When the hands have once been disinfected, care should be taken not to touch other objects with them.

3. Surgical Instruments.

Now that these are made of metal, instruments can be sterilised by *boiling*, which disinfects them with absolute certainty from all pathogenic bacteria. Care should be taken to first mechanically clean

them of any dried pus or blood by *scrubbing* them with a nail-brush and lysol or carbo-sapol solution. After this they should be boiled for a quarter to half an hour in a 1% soda or a 20% carbo-sapol solution, the presence of the soda or the carbo-sapol preventing rusting and blunting of the instruments. For boiling, the instruments may be wrapped in a towel to facilitate their subsequent removal, if there is no tray for them. When taken out of the steriliser they are placed in sterile water. Care should be taken with knives and needles, as they may be blunted by being knocked against other instruments during boiling. The former should be wrapped separately in gauze or placed in a rack, while the latter may be stuck into a piece of lint. Some prefer to place knives, scissors, and needles in 1–20 carbolic lotion to avoid the possible blunting caused by boiling. After an operation, the instruments should be *scrubbed* with a nail-brush in carbo-sapol solution, dried, and put away into the instrument case after being boiled.

4. Aseptic Lotions.

In *aseptic surgery* chemical lotions are used as little as possible, and for washing wounds, when that is needed, (*a*) *normal saline solution* and (*b*) *sterile water* are employed. When antiseptics are used, the ones employed may be different solutions of the

biniodide of mercury, or of carbolic acid according to the choice of the surgeon.

5. Sponges.

Artificial sponges made of *gauze* or of *absorbent wool wrapped in gauze* are now almost entirely used in surgery. They are sterilised by boiling in 1% soda solution. At some operations bits of dry sterilised gauze are used for wiping the wound surfaces and then thrown away.

6. Surgical Accessories.

1. LIGATURES.—*Silk* is sterilised by boiling in 1% soda solution for 15 minutes. *Catgut.*—Various methods are adopted, but boiling in alcohol (Jellett) in a special apparatus for an hour is very reliable. Iodised catgut is also much used.

2. SUTURES.—*Wire, silk, silk-worm gut, paragut,* and *horse hair* are boiled in 1% soda solution for 15 minutes, though some hold that silk-worm gut requires longer. *Catgut* is of course boiled in alcohol, just as for ligatures, or iodised catgut may be used.

3. DRAINAGE APPARATUS.—The decalcified bone tubes are rendered sterile in the process of preparation. The rubber tubes, the glass tubes, and the oiled silk are *boiled,* as also can be the drains of horse hair, gauze, and wool. Those of catgut are made from

material sterilised by *boiling in alcohol* or iodised. All ligatures, sutures, and drainage apparatus must be kept in aseptic solutions, and under conditions that will prevent their being contaminated before being used.

4. Dressings.—Looking to the important duty they have to perform, surgical dressings should possess (1) great absorbing power, (2) be permeable to air to allow of their drying quickly, (3) be free from pathogenic germs, and (4) be able to prevent decomposition of the albuminous wound discharges (antisepsis). Further, in view of the large quantities used, they should be inexpensive. Gauze, Wood-wool, Gamgee tissue, and lint are the materials chiefly employed, and of these gauze is undoubtedly the best. In connection with it, it is interesting to note that gauze was the substance originally selected by Lord Lister as the type of an absorbent dressing, a selection that has held its own against all the proposed substitutes for it.

To render these dressings free from pathogenic germs and make them surgically clean, heat in the form of *steam* is mainly employed. Its advantages for this purpose are many. It is certain, rapid, and simple, while its convenience is seen in that it allows of the sterilisation of the dressings being carried out in boxes (drums) so constructed that they can subsequently be hermetically closed, thus keeping every-

thing inside free from contamination. Of the three forms of steam—(*a*) nascent, (*b*) under pressure, (*c*) superheated, it is found that moderate steam pressure, say 5 lbs. per sqr. in., answers admirably, and that the time required for sterilisation of the dressings is *half an hour from the time steam is freely given off, or the thermometer registers* 100° C. In the working of the process some experience is needed, and attention to certain details, such as the preliminary warming of the dressings and their careful subsequent drying, goes a long way to ensure a satisfactory result.

The use of such *dry* sterilised dressings is considered the best protective covering that can be applied to a wound, but of late the opinion is gaining ground that the presence of an *antiseptic* in these sterilised dressings is an advantage, especially during the first day or two after operation, when wound discharges are free and the dressings, soaked with albuminous fluids, which are the best nutrient medium for micro-organisms, may become putrid (septic) and thus endanger the wound. No doubt *dryness* of surgical dressings is an ample security, as bacteria cannot thrive in the absence of moisture, but it cannot always be ensured, and possibly sterilised antiseptic dressings are the safest. Of the antiseptics used for impregnating the dressings every surgeon has his choice, but (1) a weak carbolic lotion (1–60), (2) the double salt of zinc and mercury, (3) corrosive

sublimate, and (4) iodoform are the ones most in vogue.

5. Towels, Surgical Aprons, and Costumes.—These are rendered surgically clean by *steam*, although the boiling they undergo in the ordinary process of washing renders them quite reliable. It is, however, safer to re-sterilise them in case they have been exposed to any subsequent contamination.

6. Bowls and Glass Vessels.—*Bowls* may be sterilised by boiling in the large instrument steriliser, but those of very large size must be done by steam in the steam steriliser. *Glasses* are sterilised by being placed in 1–20 carbolic lotion, as they would be damaged by being boiled or subjected to steam.

7. Nail-Brushes.—They cannot be altogether done without, but they require special care. Some, as Neuber, regard them as great sources of danger, and would banish them from surgical work. No doubt they become filled with epithelium, pus, and blood, and may be breeding grounds for bacteria, but by attention to certain points they may be rendered safe. The following rules should be observed:—

(1) Let them be of vegetable fibre, not wood or bristles, and expose them when new to *steam* for 15 to 20 minutes, or *boil* them for five minutes.

(2) If infected with blood or pus, expose them again to steam, or boil them.

(3) Keep them carefully in some protected aseptic fluid as carbolic lotion 1–40, changing it often.

(4) Have separate brushes for the cleansing of the hands, and never let them be used for anything else.

8. The Use of Sterilised Costumes by Surgeon and Assistants.—During the performance of an operation it is necessary that the surgeon, and all those assisting him, should have their ordinary clothing covered with sterilised gowns, and this practice is very generally followed. Many, however, are not content with merely a gown, but consider it necessary to wear a complete costume with cap, mask, and foot coverings. The absolute necessity for this additional raiment has not been established, and there are no grounds for thinking that without it the ordinary aseptic technique is incomplete and unreliable.

STERILISING APPARATUS.

The above is a brief outline of the procedures necessary to prevent wound infection in surgical work, and for carrying them out a certain amount of apparatus is required. With this and its working

it is important to be acquainted. The most essential articles, and the ones whose mechanism and management should be thoroughly understood, are the *sterilisers* for (1) instruments, (2) dressings, and (3) ordinary water. Various patterns of these have been brought out, and every surgeon has his own

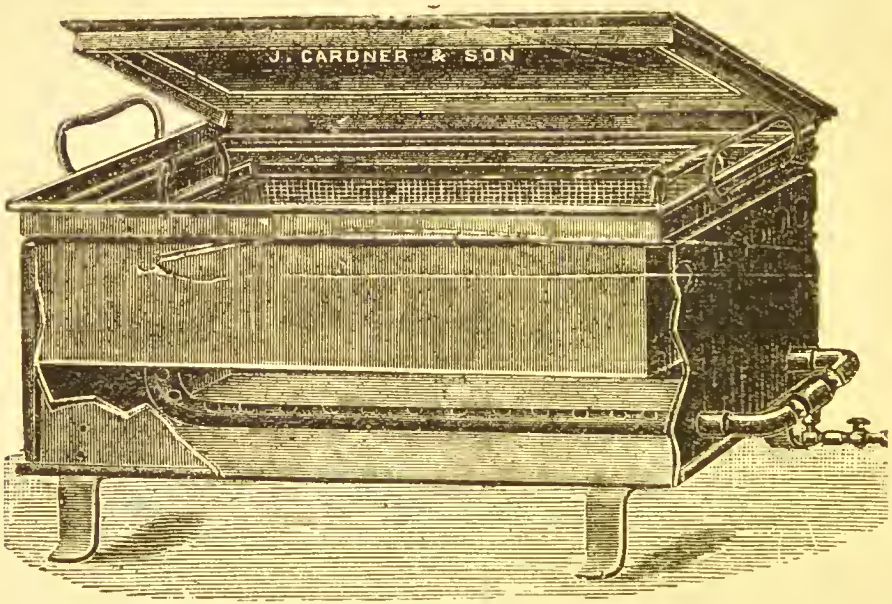

Fig 3.

particular choice, but the fact is that they have all a great deal in common, and differ only in some minor details.

Instrument sterilisers.—A great number of these have been devised, but they are nearly all based on the type of the original one brought out by

Schimmelbusch (Fig. 3). Its main features are that it is so arranged that it can be worked by either gas or steam, and it has a tightly-fitting lid to retain the heat. For holding the instruments there are wire trays, and to allow of them being lifted out of the apparatus without scalding the hands, they are furnished with wooden handles. For use the steriliser is partly filled with a 1% soda solution (a teaspoonful of common washing soda to each pint

Fig. 4.

of water serves admirably), and the heat applied. When the solution has been boiling for a few minutes, the tray or trays containing all the non-cutting instruments are placed in it and the lid replaced. The instruments are boiled for 15, 20, or 30 minutes as ordered, and then they are taken out on the trays, when they are placed in some previously sterilised vessel, or in one filled with either sterile water or with a weak carbolic lotion of 1–100.

A very useful instrument for lifting instruments out of the steriliser is Cheatle's Forceps (Fig. 4). Only instruments made wholly of metal can be so treated. As regards the cutting instruments, knives, scissors, and needles, they should be sterilised separately, if time permits, the knives being placed in a metal rack, or having their blades protected by gauze or lint. Needles may be placed in metal needle-boxes, if they are available, or passed through a piece of gauze or lint. Some hold that boiling affects the sharpness of knives and scissors, and prefer to let them lie for some time in absolute alcohol or in 1–20 carbolic lotion, only boiling them after an operation, and then sending them to be re-sharpened. The enthusiasts for heat as a sterilising agent insist that immersion in alcohol or carbolic does not render instruments sterile, but this is not the case (Watson Cheyne).

Steam sterilisers for dressings.—Whatever the dressings used, whether gauze, Gamgee-tissue, wood-wool, lint, or other materials, they should be sterilised by steam. To enable this to be done, various *steam sterilisers* have been brought out. Each has its own distinctive features, but none are reliable unless "they produce an atmosphere of saturated steam at a temperature that shall not be less than 100° C." (Pearson). This is essential to ensure reliable sterilisation of the dressings. Many

sterilisers fulfilling this requirement are on the market. Some being *high-pressure* and some *low-pressure* ones.

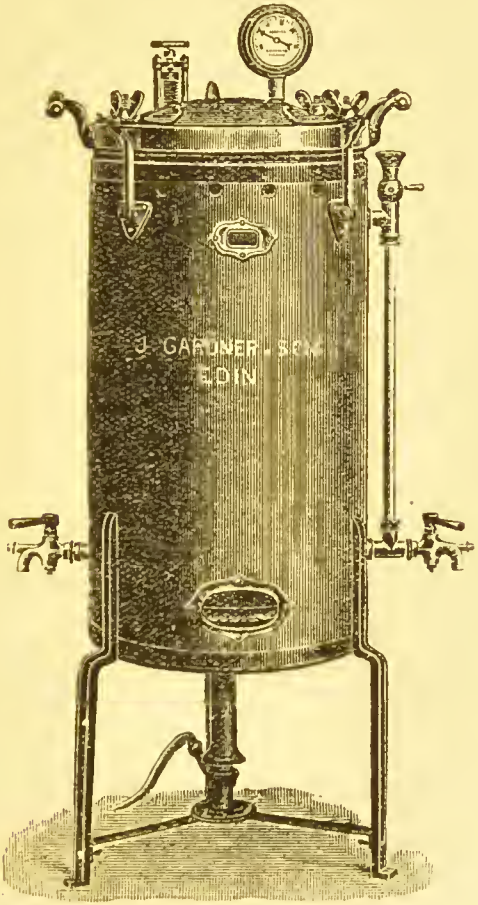

Fig. 5.

The former are no doubt more actively germicidal, but the latter are quite sufficient, if carefully and properly managed. Fig. 5 is an illustration of a

high-pressure dressing steriliser, which fulfils all the conditions of safe working, viz., easy manipulation, suitable shape, sufficient and continued pressure to completely saturate the sterilising chamber with steam, and provision for drying the dressings. It is not necessary to give in detail its working, as this is best learnt practically. All that need be said is that the dressings after being duly prepared for sterilisation are wrapped up in gauze bags or packed

Fig. 6.

in the perforated metal boxes known as Schimmelbusch's kettles or drums (Fig. 6), and submitted to the effects of the steam continuously for three-quarters of an hour at a pressure of 15 lbs. If the dressings are not packed too tightly, and are heated before the steam is allowed to enter, a continuous exposure of three-quarters of an hour

is quite sufficient. When sterilisation is complete the drums are removed from the cylinder, the lids

Fig. 7.

slightly raised, and the holes allowed to remain open for a short time, so as to ensure the dressings being thoroughly dry. After this the lids

should be tightly closed, and the holes occluded by moving the slides into position so as to exclude all dust.

Of low-pressure sterilisers, the one in most general use is that of Schimmelbusch (Fig. 7), and the unanimous verdict is that it is in every way reliable and efficient. With it in full working order a temperature of 100° C. can be obtained, and this should be maintained for three-quarters of an hour continuously to ensure complete sterilisation of the dressings. These are best placed in the drums, which are removed after sterilisation is finished, care being taken to tightly close the lids and the apertures in the drums.

Although these sterilisers were specially designed for dressings, they can be utilised for the sterilisation of towels, sheets, operating gowns, and aprons, special care being, however, taken not to pack them too tightly and thus prevent the steam permeating freely through them. In the same way the instrument steriliser may be utilised for bowls and dishes.

Water-sterilisers.—As ordinary water contains a large number of micro-organisms, some of which are pathogenic, it is necessary for surgical purposes that all water employed should if possible be sterile, or at any rate free from all pathogenic germs. Of the different methods in vogue for sterilising water, the simplest and the most convenient one is by boiling it,

and if this is done for five minutes continuously, any water so treated may be regarded as surgically safe. Special water-sterilisers (Fig. 8) are made with cooling coil, thermometer, water-gauge, Bunsen's burner, etc.,

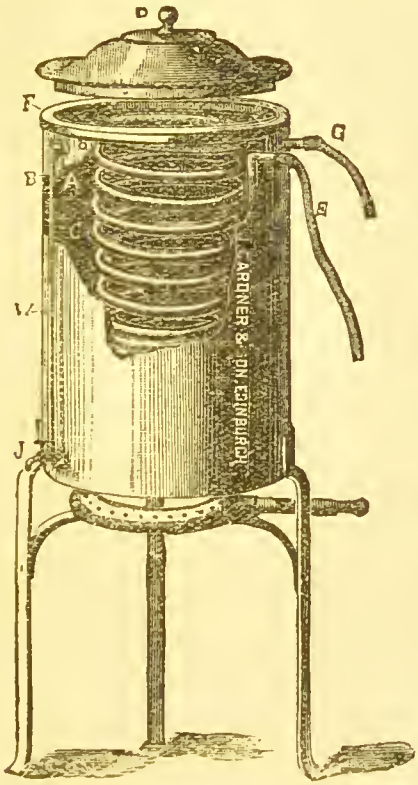

Fig. 8.

but they are expensive and are not necessary. By far the simplest plan is to have two copper vessels lined with tin and heated by gas or electricity. In one of these the water is boiled the evening before

an operation and then allowed to cool, while the other is kept boiling during the operation. In this way there is always available a sufficient supply of hot and cold water for making lotions and saline solution.

These are the main furnishings in connection with the operating theatre that call for special notice, and their proper working and management should be thoroughly understood.

CHAPTER IV.

THE TREATMENT OF ACCIDENTAL WOUNDS AND THE CONDUCT OF AN OPERATION.

TWO MAIN GROUPS OF WOUNDS.

In the present chapter I propose to indicate the method of applying the principles of modern wound treatment that have been already enumerated and explained, dealing separately with the two main groups into which it is customary to divide wounds, namely, (1) those which have not been made by the surgeon but have occurred accidentally, and (2) those made by the surgeon through unbroken and healthy skin.

I. TREATMENT OF ACCIDENTAL WOUNDS.

An accidental wound may be defined as the break or division of continuity in the tissues of the body

caused by the mechanical violence of an accidental injury (trauma). Such a wound may be *incised, punctured, lacerated,* or *contused,* but whatever its variety, apart from any special damage that the tissues have received, it may have become contaminated by those micro-organisms which are the cause of the septic diseases of surgery. Under these circumstances, the course to be followed in these cases must depend on the length of time that has elapsed between the occurrence of the injury and the date when it is first seen by the surgeon. Should that period be short, say a few hours, then an attempt should be made to destroy the organisms and correct the mischief, but if some days have passed and sepsis has occurred, then it is useless to attempt such destruction, and the proper thing to do is to counteract and miminise in every way the ill effects that the infection has given rise to or may induce subsequently. We have thus two classes of accidental wounds, each calling for somewhat different treatment when first seen.

1. **Accidental wounds seen soon after infliction.**—The best course to pursue for correcting any possible infection by micro-organisms in such a wound is to open it up thoroughly, so as to allow of the clearing out of all effused blood and of any dirt that may have been introduced at the time of the accident or afterwards. It is also advisable to cut

away any tissues that have been much bruised and whose vitality is doubtful. This having been done, the whole surface of the wound should be washed out with 1–20 carbolie lotion, or with a 1–5 spirituous solution of carbolic acid. If any of the deep parts seem badly damaged, they should be smeared over with undiluted earbolic aeid in the shape of the absolute phenol. Care must be taken to thoroughly disinfeet the skin in the vieinity of the wound. The wound itself should then be either lightly paeked with double cyanide gauze soaked in 1–60 carbolie lotion, or an attempt made to bring together its edges by sutures, ample drainage being provided for. After this, suitable antiseptic dressings should be applied and the ease managed on aseptic lines, each renewal of the dressings being carried out with every antiseptic preeaution, so as not to allow of the admission of any fresh misehief. Of the cases so treated, some do well and run practieally an aseptic eourse. In others sueeess does not follow the steps taken, and they beeome septic and suppurate. When this is the case, their management must be on the lines followed in the next elass of cases.

2. Accidental wounds seen some days after infliction.—In this elass of wound a very different state of matters has generally to be dealt with, for the micro-organisms that have gained admission when the injury was inflieted have by this time set

up deleterious changes, and there are generally present both septic inflammation and suppuration. It is useless to try and correct the infection when it has reached such a stage. All that can be done is to adopt palliative measures and minimise the effects of the sepsis. One very important matter is to provide *free and proper drainage for all discharges,* making if necessary counter-openings for their exit, and favouring their evacuation by the use of drainage tubes aided by a dependent position of the affected part.

The wound itself should be disturbed as little as possible, and it should not be washed out with strong antiseptics. Boracic acid lotion or warm saline solution are the best applications for cleansing purposes, and, as a dressing, there is no better one than warm wet boracic lint covered with jaconet and frequently changed. Under such measures the wound granulates, the discharge lessens, and eventually healing with cicatrisation takes place. These cases are somewhat tedious in their progress, and where much constitutional disturbance is present, they may call for other measures in the shape of vaccine injections. Above all special care should be taken in the changing of their dressings. Rubber gloves should be worn while this is being done, and the soiled dressings should not be thrown carelessly about. As a precaution, too, it is better to dress such septic cases

last, and if rubber gloves are not used, the hands and nails must be most thoroughly cleansed after handling such a wound.

ASEPSIS IN THE WARDS.

It must not, however, be understood that these are the only cases calling for care in their dressing. It is equally needed in every class of wound, and house-surgeons, dressers, and nurses should realise that the changing of dressings is one of the most important of all the ward duties. Hence, it should be done methodically and intelligently. Everything should be ready before the dressing of the wound is begun. The fresh dressings should have been previously cut and prepared with the greatest cleanliness and then wrapped up so as to be protected from any contamination. The necessary mackintoshes for protecting the bed should be available as well as an empty receiver for the soiled dressings, which must never be thrown about. Hands should be washed, not only before and after doing a dressing, but before handling the dressings, and nothing should be brought into contact with the wound that is not surgically clean, so that all swabs, glass syringes, nozzles of irrigators, dressing forceps, and scissors, must be sterilised and free from infection.

The patient, too, should never be unduly exposed during the dressing of the wound, and windows open

in the vieinity should be elosed. As to the proeedure to be followed in the aetual dressing of the case, this must vary with the nature of the wound and the kind of dressing in use, so that nothing definite can be laid down. There are, however, certain general principles that should be followed in the ease of all wounds, such as the one that dressings must never be removed roughly when they are adhering to a wound, and the other that the parts round a wound and not its surfaee should be washed. Lastly, that the greatest care should be taken in seeuring the dressings, so as to obviate any risk of their slipping and thus exposing the wound.

II. THE MANAGEMENT OF WOUNDS MADE THROUGH HEALTHY AND UNBROKEN SKIN.

A wound of this elass is made by a cutting instrument used by the surgeon, and is known as an "operation wound," and the point that has to be kept in view during its inflietion is the prevention of its infection by micro-organisms. The procedures necessary for ensuring this end are many and varied, and they are best grasped by outlining in general details the conduet of an operation as earried out on aseptic lines. But before doing so, it may be as well to draw attention to a few preliminary points that

apply equally to all operations both in hospital and private practice.

Preliminary Observations.

1. *An operation entails certain obligations on the surgeon.* In each case the surgeon must be alive to his great responsibility, and must exercise every care and judgment. He must conform to the best recognised method of procedure, and must especially keep in mind the special obligation he lies under to faithfully carry out aseptic and antiseptic surgery.

2. *The full consent of a patient, or of those responsible for the patient, must always be obtained for an operation.* This is an important matter and should never be overlooked. In the case of children, it may be necessary to get the consent of their parents in writing, and the same precaution holds good in the case of hysterical and neurotic patients.

3. *Certain conditions are essential to the success of all operations.* The following points should always be attended to:—

(*a*) *Make a proper selection of cases.*—This can only be done by having a fixed rule that a person cannot be regarded as a fit subject for operation and anæsthesia until a careful preliminary examination has been made, special attention being paid to the patient's

general condition, personal habits, and the state of all the individual organs in regard to present or past disease.

On this subject the late Sir James Paget wrote a classical essay (Lancet, 1867, vol. ii.), its text being:—"Never decide upon an operation, even of a trivial kind, without first examining the patient as to the risks of life that it involves." A surgeon must keep constantly in mind the fact that every operation has its risks, and that inquiry beforehand may ascertain many of them, as for example the existence of diabetes and hæmophilia.

(*b*) *Give careful preliminary attention to the patient's general health and to the part to be operated on.*—If the former is not satisfactory, operation should be delayed until improvement takes place, and in the case of the latter, any inflammation or ulceration present should be first corrected by suitable treatment before any operative measures are undertaken.

(*c*) *Influence of the season and of the weather on operations.*—The mortality of operations in the matter of the seasons and weather has been considered by Hewson, Richardson, and others, and the general conclusions

arrived at are that autumn and winter are the most favourable seasons with October as the most successful month for operating. Speaking generally the weather is a factor in operations, for great cold increases the liability to pulmonary diseases, and great heat is accompanied by affections of the abdominal viscera.

(*d*) *The best time for operating.*—Some operations must be done at once when life is threatened, as for instance a strangulated hernia, but in the cases where there is not any special urgency it is best to operate on a day fairly free from other engagements, and at an hour when there will be good light. Patients, as a rule, prefer to be operated on early in the day.

(*e*) *The place of operation.*—In hospital work a fairly wide range of operations are performed at the out-patient department, but all indoor cases are operated on in the operating theatre attached to the ward in which the patient lies. In private practice minor operations may be done in the surgeon's consulting room, but the major ones must be carried out at the patient's own house, or preferably in a nursing home. Lastly, an operation may have to

be done under "emergency conditions," the best being made of the actual surroundings. As the procedure will vary with these three different situations, it will be best to deal separately with them, and to take them in the order named, especially as an operation carried out in a modern hospital is illustrative of the modern methods of obtaining *asepsis*.

III. THE CONDUCT OF AN OPERATION IN HOSPITAL.

The number of rooms set aside for operative work varies in different hospitals, but usually consists of the operating theatre, the anæsthetic room, the sterilising room, and the nurse's store-room. In some cases we find added a dressing-room for the surgeon, a cloak-room, and an immediate preparation room. Whatever the accommodation is, the surgeon should make the best of it, remembering that operations were and still are daily performed with the greatest success without the suite of rooms and elaborate ritual thought obligatory by some. The fact is that successful results are obtained not by an operating theatre with marble walls and costly furnishings, but by skill, and by that forethought in connection with the wound, which fulfils the

scriptural injunction—"Into it there shall enter nothing that defileth."

As a successful result can only be obtained if asepsis is carried out before, during, and after an operation, there are certain routine duties connected with the patient, the operating theatre, the surgical dressings, and the actual performance of the operation itself that require special attention, and to these I will now refer, merely remarking that the bulk of them are preparatory in their nature, and fall mainly to the "theatre nurse" and to the ward nurse in charge of the case, while the others have to be discharged during the operation, and are shared by the surgeon, his assistant, and the nurses taking part in it.

1. Preparation of the patient.

A careful medical examination having decided that the patient is able to undergo the operation; the following details must be carried out:—

(*a*) Give a dose of laxative medicine on the *second evening* before the operation. If this is not possible, or has been overlooked, administer an enema of soap and water *the evening before* the operation. It is a good general rule that while a patient should never come on to the operating table with a loaded rectum, or a full

bladder, an aperient should never be given the evening before an operation, as some nursing text-books still thoughtlessly advise.

(*b*) If the doctor's sanction has been obtained, a warm bath may be taken by the patient in a properly warmed bathroom the day before the operation. This cleansing of the whole body by a thorough wash with soap and warm water is decidedly advantageous. In its absence the patient may be sponged over while in bed.

(*c*) On the evening before the operation the making of the part to be operated on "surgically clean" is carried out in the manner preferred by the surgeon, in the case of female patients by the ward nurse, and in that of males by the house-surgeon. When this has been done the field of operation must be covered by a dry sterilised dressing carefully secured in position. Should there be any accessible mucous membrane in the vicinity, it should also be cleansed, as the mouth in the case of operations on the lips or face.

(*d*) The clothing to be worn by the patient during the operation must also be "surgically clean," and it should be so arranged that it will not interfere with the performance

of the operation and yet will not unduly expose the patient.

(*e*) On the day of the operation, if a general anæsthetic is to be used, only a small quantity of light fluid food should be given not later than two hours before the operation. In the case of an operation on the stomach, special preliminary treatment may be needed. It is a good plan also, when possible, to carry out some disinfection of the mouth by brushing the teeth and by the use of a mouth-wash of warm boric lotion. Pneumonia from aspiration during anæsthesia of septic material from the mouth is not unknown (Kocher).

(*f*) It should always be remembered that on the day of operation moral support and cheerful encouragement are the greatest help and comfort to many patients and favour quiet anæsthesia.

2. Preparation of the materials required at an operation.

This is the duty of the theatre nurse. She will, of course, always have by her in the store-room an "emergency" stock that will be available for an immediate and unexpected operation; but, where time

permits, she will on the evening before each operation sterilise all the materials required the next day. She will do so with all the necessary precautions in the matter of her hands and clothing, and on the principles laid down in the chapter on asepsis and antisepsis, where it was pointed out that all materials which have been effectively boiled or submitted to a current of steam for a time, ranging from half-an-hour to one hour, are freed from all infective germs, and are rendered sterile for surgical purposes. This will be done in the dressing steriliser provided, the various materials being put up in bundles and loosely packed in the drums, which will then be put in the steriliser and submitted to the necessary heat. Included in these sterilisable materials are dressings, such as gauze and Gamgee tissue, bandages, sheets, towels, operating gowns, and linen masks. Rubber gloves are best boiled, and mackintoshes should be made surgically clean, by sponging their surface with 1–20 carbolic lotion.

As marine sponges are now entirely abandoned in surgical work, no directions need be given of the involved processes necessary to prepare them for use during an operation. Their place has been taken by squares composed of several layers of gauze stitched together, and having a tape fixed at one corner or tied round the centre of the sponge, or by swabs made of cotton-wool tied

in gauze, or by small squares of gauze in several layers. All of these varieties are convenient, and they can be completely sterilised by heat. After sterilisation, and after they have dried, great care must be taken that they are not subsequently contaminated, either by handling with unsterilised hands or in any other way. They must either be kept in the drums, or carefully protected by sterilised coverings, if removed from them. The sutures may be also sterilised the evening before, or on the morning of the operation with the instruments.

3. Preparation of the operating room.

In hospitals and nursing homes the selection of a room for operating in does not arise, as there is an operating theatre specially arranged for the purpose, and in charge of it there is placed a "theatre nurse," who has no ward work to do. To prepare it, however, for an operation, there is an antisepsis of it and of its furnishings that must be carried out partly on the evening before and partly on the day of the operation. This antisepsis is based on the principle that the micro-organisms to be dreaded in surgical work are of a special kind, and that they are on the surfaces of all substances exposed to the air. In other words they are on our hands, our clothing, and on

instruments and surgical dressings, or accessories that are lying about uncovered. In short, they are on everything upon which dust can settle. From this it follows that contamination of a wound may be caused by the patient's own skin, if it is not properly disinfected, or by *local contact* with the hands and clothing of the surgeon, of his assistants, or of the nurses, should micro-organisms be present on them. The same holds good with the instruments, the sponges, the ligatures, the sutures, or any of the other surgical accessories used in an operation. There are, however, two other points connected with micro-organisms that come into play in the antisepsis of the operating room, and it is important that they should be utilised. The first one is that micro-organisms do not float in the air, and are only found in it when they have been temporarily carried there by atmospheric currents. Consequently, just as wards should not be brushed immediately before the cases are "dressed," and in them all draughts prevented, so, in the case of the operating theatre, it should be kept absolutely quiet for some hours before an operation, and in it likewise all currents of air should be avoided, especially during the performance of the operation. The second point is that micro-organisms are not given off from moist surfaces, a fact that suggests the advisability of hosing

with water the floor and lower parts of the walls of the theatre a few hours before the operation.

4. **Taking first the preparation to be done on the evening before the operation,**

the following details should be carried out by the theatre nurse:—

(*a*) She should wipe over with an antiseptic solution and then dry all the furnishings of the theatre, such as chairs, tables, etc.

(*b*) She should sterilise all the bowls, basins, and glass vessels, the latter being placed in a pail containing 1-20 carbolic solution, but the bowls and basins being boiled or steamed in the instrument or dressing steriliser according as their size necessitates.

(*c*) She should, the last thing before leaving, hose with water the floor and lower parts of the walls of the theatre, and should arrange that it be left undisturbed for the rest of the night.

5. **On the morning of the operation the chief preparation of the theatre takes place,**

and careful attention is given by the nurse to the following points:—

(*a*) *Ventilation.*—In view of the dangers of a dust-laden atmosphere, all currents of air,

especially over the operating table, must be avoided.

(*b*) *Temperature.*—This is kept at 60°-63° F.

(*c*) *Arrangement of the furnishings.*—These consist of an operating table, side tables, bowls, hand-basins for lotions, suitable trays for instruments, receptacles for dirty dressings or fluids, jugs for hot and cold water, bowls, basins, and glass vessels of different sizes. The method of arranging the above varies, but the most convenient plan is to place the operating table in the centre of the theatre, and to group round it the other side-tables on which must be placed the instruments, dressings, towels, sheets, mackintoshes, operating-gowns, rubber gloves, and the various bowls and glass dishes.

(*d*) *The making up of the operating table.*—This is best done just before the surgeon's arrival. Everything used must be "surgically clean," but the plan followed varies with individual opinion and the case to be operated on. The table must be made comfortable for the patient to lie on, so that there must be a pillow at the head and sheets as a covering. If possible, blankets should not be used, as they retain

dust and dirt, are difficult to sterilise, and are apt to have fibres of the wool detached from them. When employed they should be carefully enclosed in clean sheets fastened by safety pins. For securing the patient's limbs, broad bandages or straps should be provided, as also a supply of hot-water bags fitted with flannel covers, and filled with water moderately warm, *so as not to cause burns on the insensible patient.*

(*e*) *The "setting" of the anæsthetist's table.*—On this table or stand are placed (1) the anæsthetic to be employed (usually in a graduated stopper bottle), (2) the apparatus used for administering it, (3) a pair of tongue forceps, (4) a hypodermic syringe with tabloids of strychnine and digitalin, (5) sulphuric ether, (6) tin of mustard leaves, (7) mouth-gag, (8) capsules of nitrite of amyl, and (9) a bowl for any vomited matters.

(*f*) *The selection and sterilisation of the instruments.*—Each operation requires its own particular instruments. These, after selection are sterilised by boiling, and then placed in a suitable tray or trays containing sterilised water, or 1-40 carbolic lotion.

If the instruments are in a large tray, they should be arranged in groups, the cutting instruments being placed together, the pressure forceps together, etc. If small suitable trays are available, the instruments can be put separately in these. It facilitates the handing of them to the surgeon. Instruments should be counted, and a list of them made at this time.

(*g*) *Provision of the necessary "surgical accessories."* —At every operation there must be a sufficient supply of sterilised ligatures, sutures, drainage-tubes, sponges, dressings, bandages, towels, sheets, mackintoshes, operating gowns, and rubber gloves, and it is important to have them conveniently and methodically arranged so as to be readily available when wanted. They ought also to be protected by suitable coverings, or antiseptic fluid, so as not to be contaminated by any dust. Included in the surgical accessories are the requisite lotions, and normal saline solution. These should be freshly prepared with sterilised water, and care should be taken to wipe over with a clean sterilised towel all the bowls, basins, jugs, and glasses in which they may be placed. They should also be

carefully identified by suitable glass lotion labels.

(*h*) *Special articles that should always be in the operating theatre.*—(1) Transfusion apparatus, (2) irrigating apparatus, (3) sterilised test-tubes and stand, (4) specimen bottles, (5) saturated solution of corrosive sublimate and absolute alcohol, (6) styptic cotton, (7) sacral rest, (8) Clover's crutch, (9) syringes, (10) tracheotomy tubes.

The above comprise the chief preliminary arrangements required before the performance of an operation, and it is necessary that the person carrying them out should exercise the same attention to surgical cleanliness in the matter of hands, clothing, and other details as are called for during the actual performance of the operation. In other words the theatre nurse should work with sterilised hands, and in a clean gown.

As to the actual position of the operating table, the grouping around it of the side tables for the lotions, instruments, and dressings, the placing of the hand-basins for cleansing the hands before and during the operation, and the other necessary details, they all depend, as already mentioned, on the nature of the operation, and may vary with each individual case, but the accompanying diagram (Fig. 9) shows a convenient arrangement. The illustration

(Fig. 10) opposite represents the area of the operating theatre in the out-patients department of the

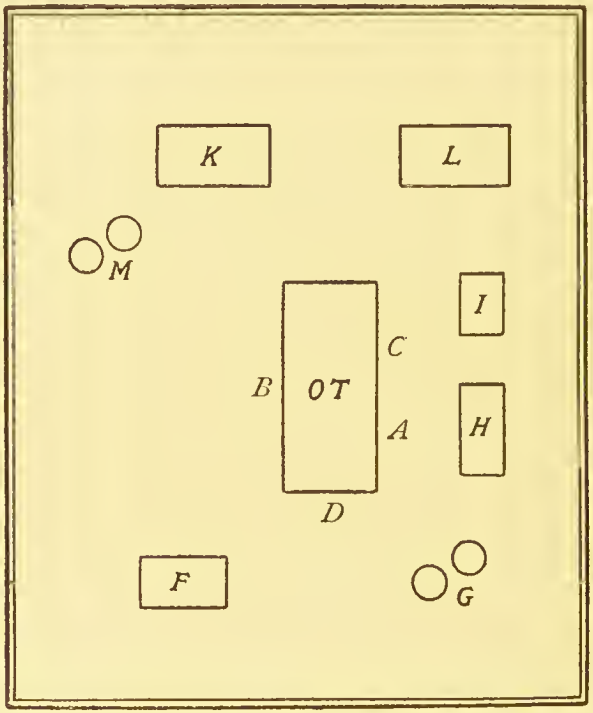

FIG. 9.

A = Surgeon.	*H* = Instrument Table.
B = First Assistant.	*I* = Extra Instrument Table.
C = Second Assistant.	*K* = Dressings' Table.
D = Anæsthetist.	*L* = Table for Towels, etc.
F = Anæsthetist's Table.	*M* = Sponge-basins.
G = Hand-basins.	*OT* = Operating Table.

Western Infirmary, Glasgow, with the furnishings similarly placed.

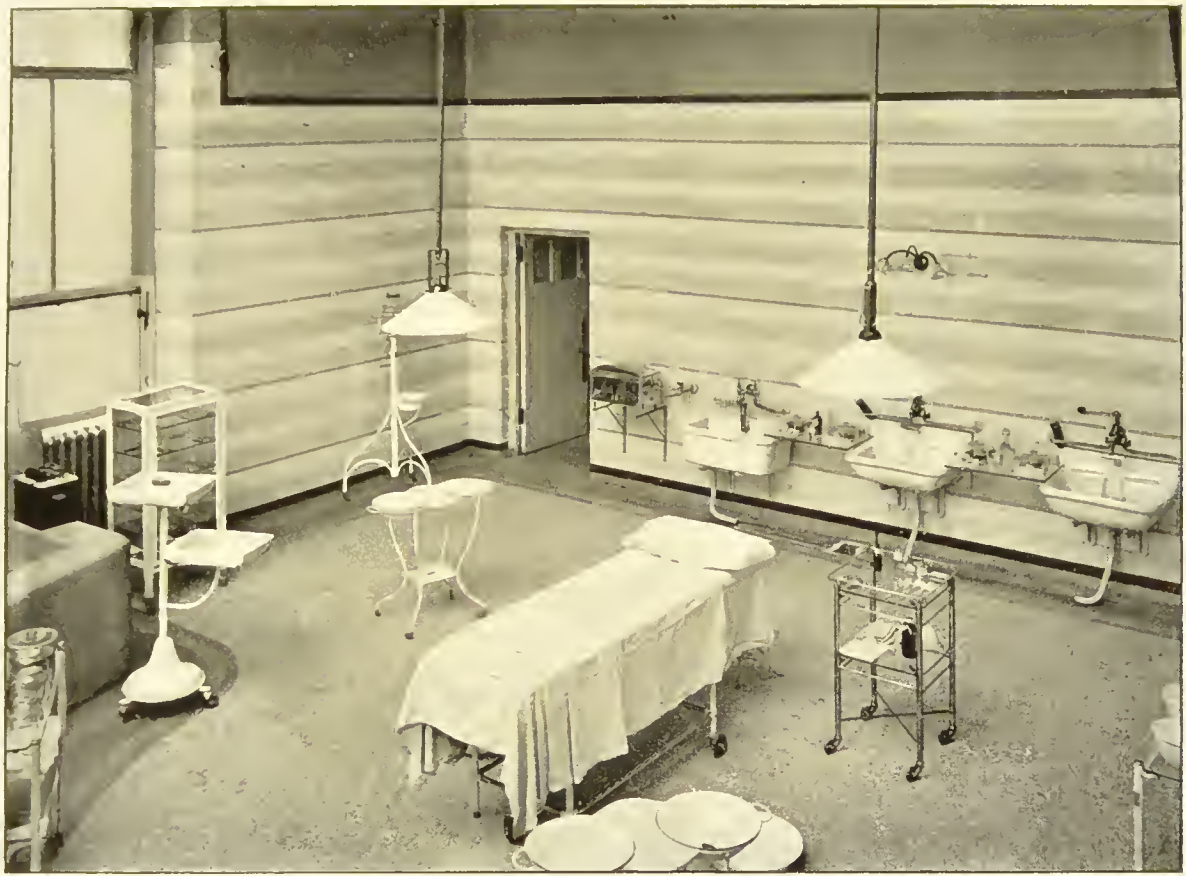

FIG. 10.—AREA OF OPERATING THEATRE.

By kind permission from Dr D. Mackintosh's "Construction, Equipment, and Management of a General Hospital."

6. The operating staff and their duties.

Before enumerating the actual steps of an operation, it is advisable to emphasize the fact that every one taking part in it should have an exact knowledge of what his or her duties are. Nurses especially have to bear in mind that each of them has her own definite work, and that she is not there to see the operation, but to assist in carrying it out by supplying wants and, if possible, foreseeing them.

The staff required by the surgeon at a major operation should, if it is possible, consist of a first and second assistant, an anæsthetist, and four nurses. The first assistant usually stands at the opposite side of the table to the operator, and performs the duty of sponging, holding retractors, and disengaging artery forceps as the ligatures are tied. He should make it his aim to in every way facilitate the actions of the surgeon, and upon this he should focus all his thoughts. The second assistant takes up a position on either side of the surgeon, just as occasion requires, and helps to hold retractors, or he cuts ligatures short after they are tied. He may also help in other ways.

The anæsthetist is responsible for the choice of the anæsthetic and its administration, and must report the advent of any unfavourable symptoms

to the surgeon. It rests, too, with him to say when the patient is ready for the operation to begin.

To the nurses it is customary to assign distinct duties. The senior one, usually the sister in charge of the wards, looks after the instruments and the other surgical accessories, handing them to the surgeon as required. She may do so by the aid of a forceps, or with gloved hands, according to the surgeon's wish. She removes all soiled instruments, and replaces them in the tray after rinsing them in a basin of weak carbolic. It rests with her, too, to take a preliminary count of the instruments, and to order the renewal of any lotions during the operation, and to take a general supervision of the other nurses, to one or two of whom must be given the important duty of attending to the sponges. With dry swabs only one nurse is needed, but when a limited number of gauze sponges are used they need to be washed, and for this two nurses are required, as well as two basins. One of them devotes herself entirely to their cleansing, while the other, standing on the left of the chief assistant, hands them to him and takes away the soiled ones. This she does by means of two bowls, which she holds in the palms of her hands, one containing the clean sponges and the other receiving the soiled ones. It rests with this nurse to *count* the sponges both before and after the

operation, and it is most important that this counting be done correctly. The only way to ensure accuracy is to have it done by *one* nurse who has two basins side by side. After putting *all* the sponges into one of them she transfers them one by one to the other empty basin, each sponge being counted audibly. The nurse is then able to say exactly how many sponges she has, and how many short she is of the original number, should she not have them all. In abdominal operations there must never be any mistake in this matter, and it is a good plan to recount the sponges before closing the abdomen. As the "theatre nurse" is usually present at the operation, she takes a part in it. She removes the temporary preliminary dressing when the patient has been rendered unconscious, and she helps to arrange the sterilised towels with their mackintoshes which surround the field of operation. During the operation she gives the sister any required help, and at the end of it she hands the dressings to the surgeon, who secures them on the wound. Besides the above nurses it is important to reserve one nurse for carrying out a number of duties that must interfere with the asepsis of her hands, such as attending to doors or windows, fetching and carrying bowls and jugs, sterilising any additional instruments, and renewing lotions. It is customary to distinguish

this nurse by a jaconet overall, and she is sometimes spoken of as the "solution nurse."

In every operating theatre there is usually a gallery for students and visitors, but if any of them come on to the floor of the theatre they must wear overalls supplied by the theatre nurse. One other point that should have attention is that the patient should be well covered and carefully protected from cold while being taken to and from the operating room.

7. The performance of the operation.

The above preliminaries being completed, and everything ready, the operation is proceeded with. The actual steps of it may be briefly summarised as follows:—

(*a*) *The anæsthetising of the patient.*—There is usually an anæsthetic room in which this is carried out, but if not, and the patient has to come direct into the theatre, then all instruments should be covered over with sterilised towels. At least two of the nurses should be beside the patient while the anæsthetic is being given in case of any struggling, but it should be remembered the movements are mainly reflex, and they should be *guided* rather than *restrained* by violence. When practically

unconscious, the patient is wheeled from the anæsthetic room and placed on the operating table.

(*b*) The surgeon, assistants, and nurses, are meanwhile carrying out *personal asepsis* as to hands and fore-arms and the putting on of sterilised suits, masks for the face and caps being used where these are deemed necessary by the surgeon.

(*c*) The next procedure is the removal of the temporary dressing and the fresh sterilisation of the field of operation, after which the surgeon determines the best *position* for the patient, and covers the vicinity of the operation area with sterilised towels having mackintoshes beneath them.

(*d*) Then follows the planning of the incisions and the necessary cutting, accompanied by the *arrest of hæmorrhage* by ligature or pressure, with the subsequent *drainage* (if necessary) and *suturing* of the wound. After the completion of the operation suitable dressings are applied and kept in position by bandages, which are in their turn securely fixed by safety pins.

(*e*) When sufficiently recovered from the anæsthetic and from any "shock" or collapse, the patient is removed to bed, care being

taken to prevent exposure to cold and that the bed has been properly prepared. Such an "operation bed" as it may be called should be made up with clean linen, and should have the bed-clothes folded either over to one side, or downwards over the end of the bed, so that the patient may be easily and quickly placed in it. It should also have a draw sheet and mackintosh placed in a position corresponding to the wound. Any pillows used in the bed for supporting any part should be protected by mackintoshes. There should be hot bottles, at not too high a temperature lest serious burns be caused to the patient, and a heated blanket to cover the patient is often of great service. Blocks for raising the end of the bed should also be at hand, and after a prolonged and serious operation hot saline solution should be in readiness. In most cases a bed-cradle is needed to support the weight of the bed-clothes and should be provided.

8. The after-treatment.

(*a*) *Immediate after-treatment.* — The patient having been placed in bed and made comfortable there, the following details

should be carried out:—(1) A nurse should remain *at the bed-side* until consciousness returns; (2) careful watch should be kept for any "shock" or collapse, and for any hæmorrhage; (3) provision should be made for chloroform sickness and its management; (4) no food should be given immediately after the operation, thirst being relieved by washing out the mouth with warm water; (5) pain and restlessness is often relieved by a moderate dose (10–15 grains) of phenacetine.

(*b*) *After-treatment proper.* — This begins with the return of the patient to consciousness and sensibility, and is conducted on certain general principles, which hold good with all cases. Special cases, however, require special details of management in addition, as for instance, operations on the brain and on the air-passages, and those that have undergone abdominal section. After-treatment proper takes in such questions as those of diet, posture, pain, sleeplessness, stimulants, management of the bowels, renewal of dressings, and many other points that could not be dealt with at length in a chapter devoted to the conduct of an operation. All that

need be said is that on the points just mentioned, instructions will be given by the surgeon to the nurse in attendance, whose duty will be to follow them out, and by careful nursing help on the patient's recovery. In surgical cases, the occurrence of hæmorrhage and the prevention of bed-sores are two of the main points that should engage the nurse's attention, and when the renewal of the dressings has to be carried out she will see that there is the same rigid asepsis and antisepsis that was deemed necessary at the operation itself.

IV. THE CONDUCT OF AN OPERATION IN A PRIVATE HOUSE.

There are cases in which the operation has to be done in the patient's own house, and, though the procedure is not so easy, the general experience is that, with proper care and management, sepsis can be avoided, and a satisfactory result obtained. Here especially is the help of one or more skilled nurses required. Assuming that there is no clamant hurry in the case, and that sufficient time is available, everything should be done in a methodical manner.

1. The preparation of the patient should be carried out in the way already indicated.

2. A suitable room should be selected, and in deciding this matter attention should be directed to its accessibility, its size, its light, its connection with the drains, and the supply of hot and cold water near it, and the ability to heat it, if required.

3. The preparation of the room need not be on an extensive scale. The day before the operation it should be thoroughly cleared out, carpets being taken up, and all pictures, curtains, and unnecessary articles removed. The floors too, should be washed, and the room dusted with moist cloths. It should then be shut up and the dust allowed to settle.

4. The necessary furnishings should consist of (*a*) operating table, either a portable one brought by the surgeon, or an extemporised one in the shape of a narrow kitchen table; (*b*) three small tables for dressings, instruments, and the anæsthetist, with a few chairs on which basins and bowls can be placed; (*c*) a couple of wash-hand stands; (*d*) and two foot baths or pails as receptacles for soiled swabs and fluids.

5. The materials required at the operation, such as the sheets and towels, the hot and cold sterilised water, can be supplied by the household, but the dressings, lotions, towels, aprons, bandages, and

other articles needed must be sterilised at a nursing home or elsewhere and sent in.

6. The actual arranging and preparation of the room for the operation should be done a few hours previously by the nurses, who should make up the operating table, lay out the instruments and dressings, and have everything in readiness.

7. The actual performance of the operation will be on the lines already indicated. During the anæsthetising of the patient, the surgeon and his assistants will carry out their personal asepsis, as also the nurses, as soon as they are freed from attending on the anæsthetist. After the area of operation has been protected by sterilised towels, the surgeon will proceed with the operation in the usual way, and all the steps of it will be exactly on the lines already described. Compared with the facilities offered by the modern operating theatre, an operation conducted in a private house presents some difficulties, but they are not insuperable, and a skilful and resourceful nurse will readily overcome them, while at the same time not unnecessarily disturbing the household arrangements.

V. THE CONDUCT OF AN OPERATION UNDER EMERGENCY CONDITIONS.

An operation may have to be done under circumstances where there may be very little time

to make preliminary preparations, and where there may be a complete lack of necessaries, as for instance, the relief of a strangulated hernia or an amputation in a remote country district.

Although tempted to despair of carrying out *asepsis* under such an unfavourable conditions, the comforting reflection should present itself that a situation such as this can be satisfactorily met, because it furnishes, as Lejars says, "*fire*, *water*, and *linen*, to say nothing of *salt* and often baking soda," so that "with these the instruments, the dressings, the operator's hands, and the patient's skin can all be sterilised quite satisfactorily." The chief point to keep in mind is that there must be method in all that is done. Given a lighted fire and the use of saucepans and other vessels, basins, bowls, and plates, with a supply of handkerchiefs, napkins, towels, and water, there should be no difficulty in furnishing dressings "surgically clean" for applying to the wound and providing a sterilised area of operation.

With a little management, too, the patient can be sufficiently prepared, and an operating room and operating table got ready, and all the other requirements fulfilled for giving that exclusion of micro-organisms from the wound that provides safety and quick healing. In short, the rule should be in these emergency cases to avoid in every way the disturb-

ance of dust, and to trust to boiling as a means of rendering everything surgically clean.

Acting on these principles excellent results can be obtained, remembering also what should be constantly borne in mind that we must never regard operative surgery as a mere *art*. It has its scientific side in the proper selection of cases, in the conduct of operations, in the after-treatment of patients, and in meeting complications that may arise. All these matters demand attention, and if they do not receive it, no manual dexterity will bring an operation to a successful termination.

HINTS ON ASEPTIC AND ANTISEPTIC SURGICAL TECHNIQUE.

1. The operating theatre should have special care from the nurse in charge in the matter of keeping its floor, its walls, and its furniture clean, and in order. Especially should the instrument case be inspected from time to time, and dusted.

2. At operations every nurse should devote herself to the duties assigned her, and to nothing else, but should make herself thoroughly acquainted with the whole conduct of an operation.

3. Particular care should be taken in the cleansing of instruments after an operation, and in the washing and tidying of the theatre.

4. The storage of all the stock dressings, and of the surgical accessories should be closely attended to. They should be protected from dust by sterilised sheets, and by being placed in boxes, or in vessels with properly fitting lids when stored in fluids, as in the case of sutures, ligatures, and drainage-tubes. If 1-20 carbolic lotion is used, as is commonly the case, the lotion should be renewed from time to time.

5. As surgical dressings are expensive, the greatest economy should be exercised in their use, and they should only be handled with hands that have been made surgically clean.

6. Mackintoshes should not be placed in the steam steriliser, but should be cleaned with pumice stone soap and water, then washed with 1-20 carbolic lotion, and finally dried.

7. All lotions should be made with boiled or sterilised water, and there should be a constant supply of cold sterilised water available for diluting them if needed during an operation or the dressing of the cases in the wards.

8. The greatest care and accuracy should be exercised in the labelling of lotions, both to prevent accidents, and to ensure the asepticity of the wounds during operation, and subsequently in the wards.

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